ENERGY AUDIT OF ARMY INDUSTRIAL FACILITY (EEAP)
DETROIT ARSENAL TANK PLANT, BUILDING 4
WARREN, MICHIGAN

Final Report
Executive Summary

DEPARTMENT OF THE ARMY
LOUISVILLE DISTRICT, CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

September 27, 1985

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1. EXECUTIVE SUMMARY

1.1 Introduction

The Detroit Arsenal Tank Plant is located in Warren, Michigan, a suburb of Detroit. The Detroit Arsenal, of which the tank plant is a part, is the headquarters for U. S. Army Tank Automotive Command (TACOM). The total facility has 105 buildings, the tank plant, Building 4, is the largest at 1,114,000 square feet.

Building 4 is the final assembly facility for the production of M1 and M60 tanks. Components and subassemblies are shipped from subcontractors and the Lima, Ohio tank facility for final assembly at the Warren, Michigan facility. The main function of the plant is assembly with related support areas such as heat treat, welding, painting and machining.

The plant has been producing tanks since 1941 when the first M3 tank was deliverd in April and with full production starting in July. The plant has produced M3, M4, M47, M48, M60, M60H2 and M1 tanks since 1941 to the present. Prior to General Dynamics taking over the operation in 1982, the facility was operated by Chrysler Corporation.

The original concept was based on the automotive industry assembly line and was very successful for many years in turning out very high volumes of tanks. With the increasing complexity of the tank due to modern technology, the volume decreased substantially until today, the assembly of the tanks is more of a job shop operation rather than a fast

moving assembly line operation. The plant is operated on three shifts, five days a week. The third shift is not a full shift.

Since energy costs have risen dramatically from 1973 and future projections indicate that these costs will continue to rise, energy conservation measures need to be implemented to hold down the operating costs of the facility. Building 4 at the Detroit Arsenal has many varied environmental and process systems that offer the possibility of energy conservation opportunities to be identified, quantified and offered for consideration for implementation through an energy conservation analysis. Smith, Hinchman & Grylls Associates, Inc. of Detroit, Michigan was commissioned to perform this analysis on Building 4.

The heating media for the facility is low pressure steam. Air handling units with heating coils and unit heaters provide the heating requirements. Building and process ventilation is provided by dedicated exhaust systems and through the building monitor system. Cooling is provided for specialized areas such as computer rooms, testing and the general offices.

In performing the energy conservation analysis, many on-site visits were made to gather data of present and past energy use, to interview facility operating personnel on the mode of operation of the facility, and to survey and record data pertaining to Building 4 HVAC and process equipment.

The following report is the result of the energy conservation analysis.

1.2 Historical Energy Consumption

1.2.1 Introduction

The recorded energy history is useful for predicting energy consumption when production levels change or when energy conservation opportunities are implemented. Building 4 lacks a good base of energy consumption data. Data was obtained from the boiler house reports for the period September 1982 to March 1985. Because of the lack of positive metering, this data is used as a basis of analysis, but should be updated once a positive metering program is implemented. (See Facility Energy Consumption, Section 6 of Narrative Summary.) The energy history for Building 4 is presented graphically in Figure 1.1 and Figure 1.2.

Figure 1.1 shows consumption in terms of type of energy consumed at Building 4 and Figure 1.2 is in terms of source energy.

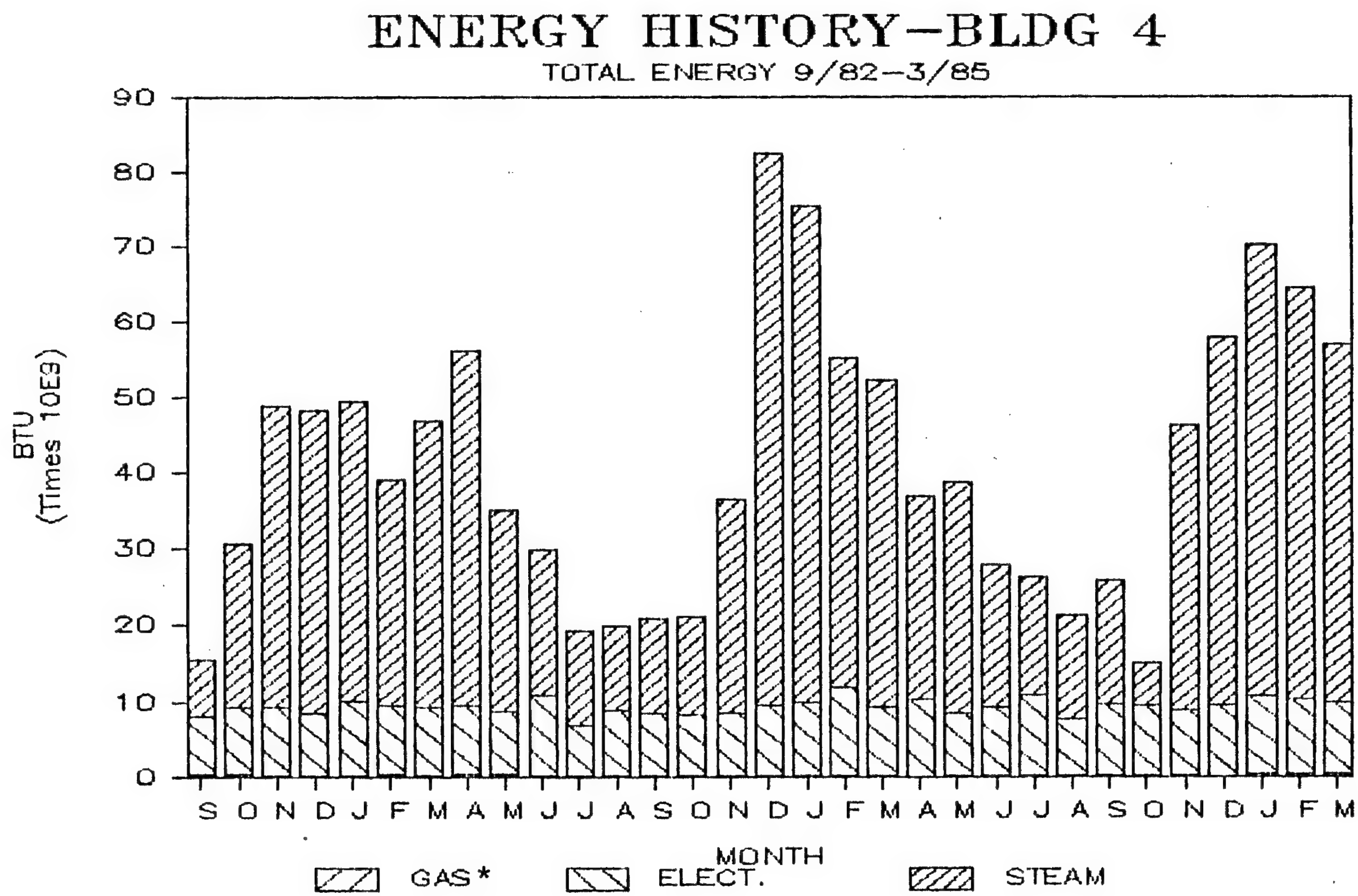
1.2.2 Electrical Consumption

Electrical consumption records are kept at the boiler house (see Boiler House Report Summary, Appendix A, Section B). A summary of the electrical consumption data is presented in Table 1.1. Monthly consumption ranged from 1,996,000 kWH in July 1983 to 3,448,800 kWH in February 1984.

1.2.3 Natural Gas Consumption

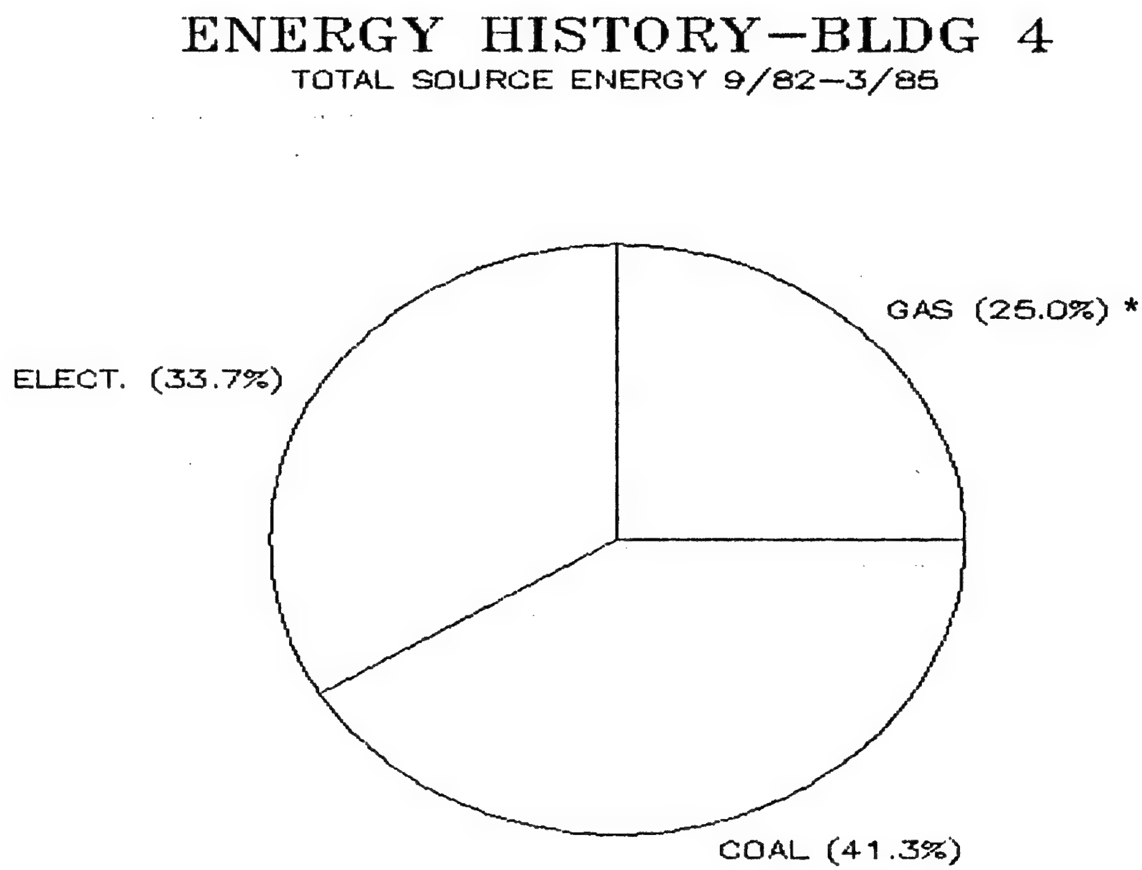
Natural gas is consumed at Building 4 in the heat/surface treatment area. Gas consumption is metered to Building 4 and is recorded at the boiler house (see Boiler House Report Summary, Appendix A, Section B). Monthly consumption ranged from 38,000 cubic feet in December 1984 to 398,500 cubic feet in May 1985 (see Table 1.2).

Figure 1.1



* NOTE: Gas is a small portion of monthly energy consumption and is barely visible at the bottom of the graph.

Figure 1.2



* NOTE: In this graph, "gas" consists of two components--production and steam generation.

Table 1.1

ELECTRICAL CONSUMPTION - HISTORICAL

Month	Consumption kWH	Consumption 10^6 Btu*
Sep 1982	2,296,800	26,642.88
Oct	2,613,600	30,317.76
Nov	2,630,400	30,512,64
Dec	2,419,200	28,062.72
Jan 1983	2,942,400	34,131.84
Feb	2,677,333	31,057.06
Mar	2,677,333	31,057.06
Apr	2,677,333	31,057.06
May	2,488,800	28,870.08
Jun	3,136,800	36,386.88
Jul	1,996,800	23,162.88
Aug	2,565,600	29,760.96
Sep	2,496,000	28,953.60
Oct	2,412,000	27,979.20
Nov	2,440,800	28,313.28
Dec	2,719,200	31,542.72
Jan 1984	2,877,600	33,380.16
Feb	3,448,800	40,006.08
Mar	2,697,600	31,292.16
Apr	3,016,800	34,994.88
May	2,450,400	28,424.64
Jun	2,692,800	31,236.48
Jul	3,170,400	36,776.64
Aug	2,232,000	25,891.20
Sep	2,820,000	32,712.00
Oct	2,707,200	31,403.52
Nov	2,534,400	29,399.04
Dec	2,764,800	32,071.68
Jan 1985	3,043,200	35,301.12
Feb	2,918,400	33,853.44
Mar	2,779,200	32,238.72

* 11,600 Btu = 1 kWH

Table 1.2

NATURAL GAS CONSUMPTION - HISTORICAL

Month	Consumption cf	Consumption 10^6 Btu*
Sep 1982	309,013	318.59
Oct	334,700	345.08
Nov	245,600	253.21
Dec	184,800	190.53
Jan 1983	154,700	159.50
Feb	285,360	294.21
Mar	202,700	208.98
Apr	294,000	303.11
May	294,000	303.11
Jun	265,900	274.14
Jul	140,400	144.75
Aug	103,100	106.30
Sep	112,700	116.19
Oct	154,600	159.39
Nov	150,300	154.96
Dec	144,900	149.39
Jan 1984	186,800	192.59
Feb	149,700	154.34
Mar	116,800	120.42
Apr	66,900	68.97
May	86,800	89.49
Jun	132,000	136.09
Jul	80,700	83.20
Aug	156,800	161.66
Sep	169,000	174.24
Oct	218,300	225.07
Nov	206,400	212.80
Dec	38,000	39.18
Jan 1985	302,100	311.47
Feb	355,700	366.73
Mar	398,500	410.85

* 1,031 Btu = 1 cf

1.2.4 Steam Consumption

Steam is not directly metered to Building 4. Total steam production is recorded at the boiler house and steam is metered to the west site of the facility. The difference is the amount charged to General Dynamics (see Table 1.3). The amount of steam used by General Dynamics represents the total steam used on the east site. In an attempt to isolate Building 4 from the east site consumption, the annual heating load of all east site buildings was calculated. This was subtracted from the east site total steam consumption to yield Building 4 steam consumption (see Table 1.4). Because of the method of steam metering used, this consumption includes Building 4 base steam as well as the steam utilized within the boiler house.

1.2.5. FY 83 Consumption

The energy consumption for FY 83 is shown in Table 1.5. Total energy consumption for FY 83 is 688,392.37 x 10^6 Btu. This translates into the following ratios:

$$\frac{688{,}392.37 \times 10^6 \text{ Btu/yr.}}{1{,}114{,}381 \text{ sf}} = 617{,}735.23 \text{ Btu/sf/yr.}$$

$$\frac{688{,}392.37 \times 10^6 \text{ Btu/yr.}}{\frac{60 \text{ tanks}}{\text{mo.}} \times 12 \text{ mos.}} = 956.1 \times 10^6 \text{ Btu/tank}$$

Table 1.3

EAST SITE STEAM CONSUMPTION

Month	Consumption 10^6 lbs.
Sep 1982	7.980
Oct	23.036
Nov	42.558
Dec	43.869
Jan 1983	45.184
Feb	34.196
Mar	41.659
Apr	50.191
May	28.276
Jun	18.911
Jul	12.298
Aug	11.057
Sep	12.818
Oct	14.712
Nov	31.233
Dec	79.535
Jan 1984	72.756
Feb	48.091
Mar	48.695
Apr	29.361
May	31.982
Jun	18.528
Jul	15.399
Aug	13.475
Sep	16.547
Oct	21.285
Nov	41.198
Dec	53.313
Jan 1985	66.712
Feb	59.973
Mar	51.425

Table 1.4

BUILDING 4 STEAM CONSUMPTION

Month	East Site Total 10^6 lbs.	East Site Buildings Less #4 10^6 lbs.	Building 4 Consumption 10^6 lbs.	Consumption 10^6 Btu*
Sep 1982	7.928	0.496	7.432	7,432
Oct	23.036	1.613	21.423	21,423
Nov	42.558	2.995	39.563	39,563
Dec	43.869	4.108	39.761	39,761
Jan 1983	45.184	5.929	39.255	39,255
Feb	34.196	4.655	29.541	29,541
Mar	41.659	4.274	37.385	37,385
Apr	50.191	3.550	46.641	46,641
May	28.276	2.065	26.211	26,211
Jun	18.911	0	18.411	18,411
Jul	12.298	0	12.298	12,298
Aug	11.057	0	11.057	11,057
Sep	12.818	0.655	12.163	12,163
Oct	14.712	2.111	12.601	12,601
Nov	31.233	3.348	27.885	27,885
Dec	79.535	6.555	72.978	72,978
Jan 1984	72.756	7.413	65.343	65,343
Feb	48.091	4.788	43.303	43,303
Mar	48.695	5.770	42.925	42,925
Apr	29.361	2.959	26.402	26,402
May	31.982	1.856	30.126	30,126
Jun	18.528	0	18.528	18,528
Jul	15.399	0	15.399	15,399
Aug	13.475	0	13.475	13,475
Sep	16.547	0.496	16.051	16,051
Oct	21.285	1.698	19.587	19,587
Nov	41.198	3.792	37.406	37,406
Dec	53.313	4.945	48.368	48,368
Jan 1985	66.712	7.045	59.667	59,667
Feb	59.973	5.892	54.081	54,081
Mar	51.425	4.518	46.907	46,907

* 1,000 Btu = 1 lb.

Table 1.5

FY 83 CONSUMPTION

Month	Electricity 10^6 Btu	Natural Gas 10^6 Btu	Steam 10^6 Btu	Total 10^6 Btu
Nov 1982	30,512,64	253.21	39,563	70,328.85
Dec 1982	28,062.72	190.53	39,761	68,014.25
Jan 1983	34,131.84	159.50	39,255	73,546.34
Feb 1983	31,057.06	294.21	29,541	60,892.27
Mar 1983	31,057.06	208.98	37,385	68,651.04
Apr 1983	31,057.06	303.11	46,641	78,001.17
May 1983	28,870.08	303.11	26,211	55,384.19
Jun 1983	36,386.88	274.14	18,411	55,072.02
Jul 1983	23,162.88	144.75	12,298	35,605.63
Aug 1983	29,760.96	106.30	11,057	40,924.26
Sep 1983	28,953.60	116.19	12,163	41,232.79
Oct 1983	27,979.20	159.39	12,601	40,739.59
TOTAL	360,991.98	2,513.42	324,887	688,392.37

1.3 Present Energy Consumption

1.3.1 Introduction

Once the recorded historial energy consumption is analyzed, a base year, or current project energy consumption profile is developed. This is based on historical and A/E collected data. A profile is developed for each energy type as well as for the total energy consumption. The purpose of this "comparatory base" is for the evaluation of the proposed ECO's.

1.3.2 Present Electrical Consumption

Electrical consumption at Building 4 is recorded by TACOM at meters 1, 6, 8, 13, 14 and 15. These meters correspond to substations 2, 4A, 4B, heat treat, 3 and 1, respectively. To estimate the present energy consumption at Building 4, it was necessary to simultaneously meter the nine transformers associated with the above mentioned substations (see Narrative Summary, Section 6.2.2.1). This was completed for a two-week period using nine Dranetz No. 808 power demand analyzers. A representative week (April 15, 1985 to April 21, 1985) is shown in Tables 6.12 through 6.19 of Narrative Summary, Section 6.2.2. These tables show the hourly kWH readings at each transformer. These readings were used to generate Table 1.6, a two-week listing of electrical consumption at Building 4. This data was utilized to generate a monthly electrical energy consumption estimate of 2,685.109 MWH per month. (See Narrative summary, Section 6.2.2 for more detailed analysis.)

Viewing Figure 6.1 of Section 6.1 of the Narrative Summary, it is obvious that the historical electrical profile is not a straight line. Localized peaks appear in

Table 1.6

ELECTRICAL ENERGY PROFILE
(MWH)

SUBSTATION #	MONDAY 4/8/85	TUESDAY 4/9/85	WEDNESDAY 4/10/85	THURSDAY 4/11/85	FRIDAY 4/12/85	SATURDAY 4/13/85	SUNDAY 4/14/85	MONDAY 4/15/85	TUESDAY 4/16/85	WEDNESDAY 4/17/85	THURSDAY 4/18/85	FRIDAY 4/19/85	SATURDAY 4/20/85	SUNDAY 4/21/85	TWOWEEK TOTAL	ONEWEEK AVERAGE	MONTHLY ESTIMATE
1A	11.730	11.790	11.820	11.940	11.970	11.330	11.100	12.080	12.110	11.920	12.150	11.940	10.870	10.490	163.240	81.620	505.389
1B	4.837	4.855	4.882	4.814	4.951	4.740	4.704	4.984	5.025	5.037	5.258	5.494	5.303	5.312	70.196	35.098	
2A	9.321	9.920	10.310	10.660	10.110	8.868	8.244	9.297	8.753	9.235	9.935	9.925	8.728	8.026	131.332	65.666	619.155
2B	11.280	11.540	11.510	11.590	11.650	10.880	10.370	11.720	11.380	10.910	11.330	11.130	9.572	9.790	154.652	77.326	
3A	9.401	10.140	10.250	9.805	9.472	9.015	7.724	10.380	10.200	10.780	11.070	11.190	10.040	9.576	139.043	69.522	627.638
3B	10.950	11.330	11.270	11.220	11.210	10.450	10.020	10.350	10.710	11.200	10.700	11.250	10.250	9.949	150.859	75.430	
4A	18.510	19.040	19.380	18.840	18.700	16.190	15.260	18.720	18.910	19.140	18.990	18.660	17.640	15.410	253.390	126.695	548.589
4B	12.000	11.620	12.460	12.050	11.450	8.970	6.521	11.650	11.590	12.300	12.020	12.330	10.000	8.977	153.938	76.969	333.276
HEAT TREAT	1.891	1.583	1.840	1.856	1.767	1.448	1.452	1.880	1.738	2.257	1.472	1.492	1.453	1.456	23.585	11.793	51.062
TOTAL	89.920	91.818	93.722	92.775	91.280	81.891	75.395	91.061	90.416	92.779	92.925	93.411	83.856	78.986	1240.235	620.118	2685.109

January and July. This may be explained by either weather conditions or production changes. Lacking concrete historical production data, the monthly estimation of 2,685.109 MWH per month is utilized to generate the annual profile shown in Figure 1.3.

1.3.3 Present Natural Gas Consumption

The natural gas consumed at Building 4 is dependent on production as the natural gas is consumed in the heat treat area. Because of the lack of production data, the natural gas consumption in the heat treat area will be assumed to be the average consumption for the period September 1982 through March 1985. The present natural gas consumption is shown in Figure 1.4.

1.3.4 Present Steam Consumption

Steam consumption at Building 4 consists of two components: 1) base steam, and 2) heating and ventilation steam.

Base steam consists of production steam use and boiler house use. Production steam is predominantly utilized in the heat/surface treatment area. Boiler house use includes regeneration, blowoff and compressed air generation. An accurate split between Building 4 production steam use and boiler house steam use cannot be obtained at this time because the boiler house utilization is not known. Because of this, the base steam for the period September 1982 to March 1985 is averaged to obtain a flat base steam consumption profile (see Figure 1.5). Once a positive metering strategy is implemented, base steam can be divided into its component parts. (See Narrative Summary, Section 6.1.4 for more detailed breakdown of steam consumption.)

Figure 1.3

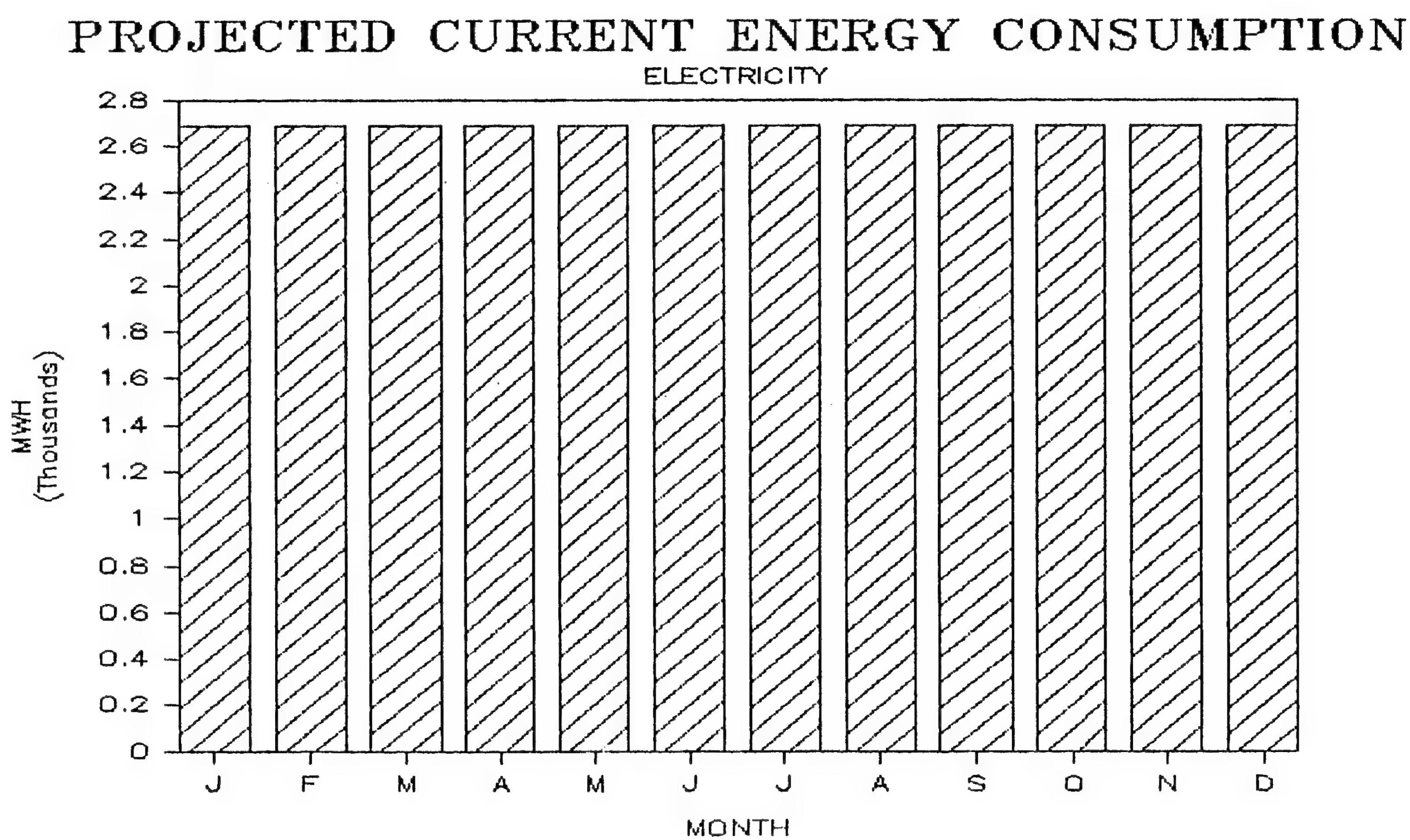

PROJECTED CURRENT ENERGY CONSUMPTION
ELECTRICITY
MWH
(Thousands)
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH

Figure 1.4

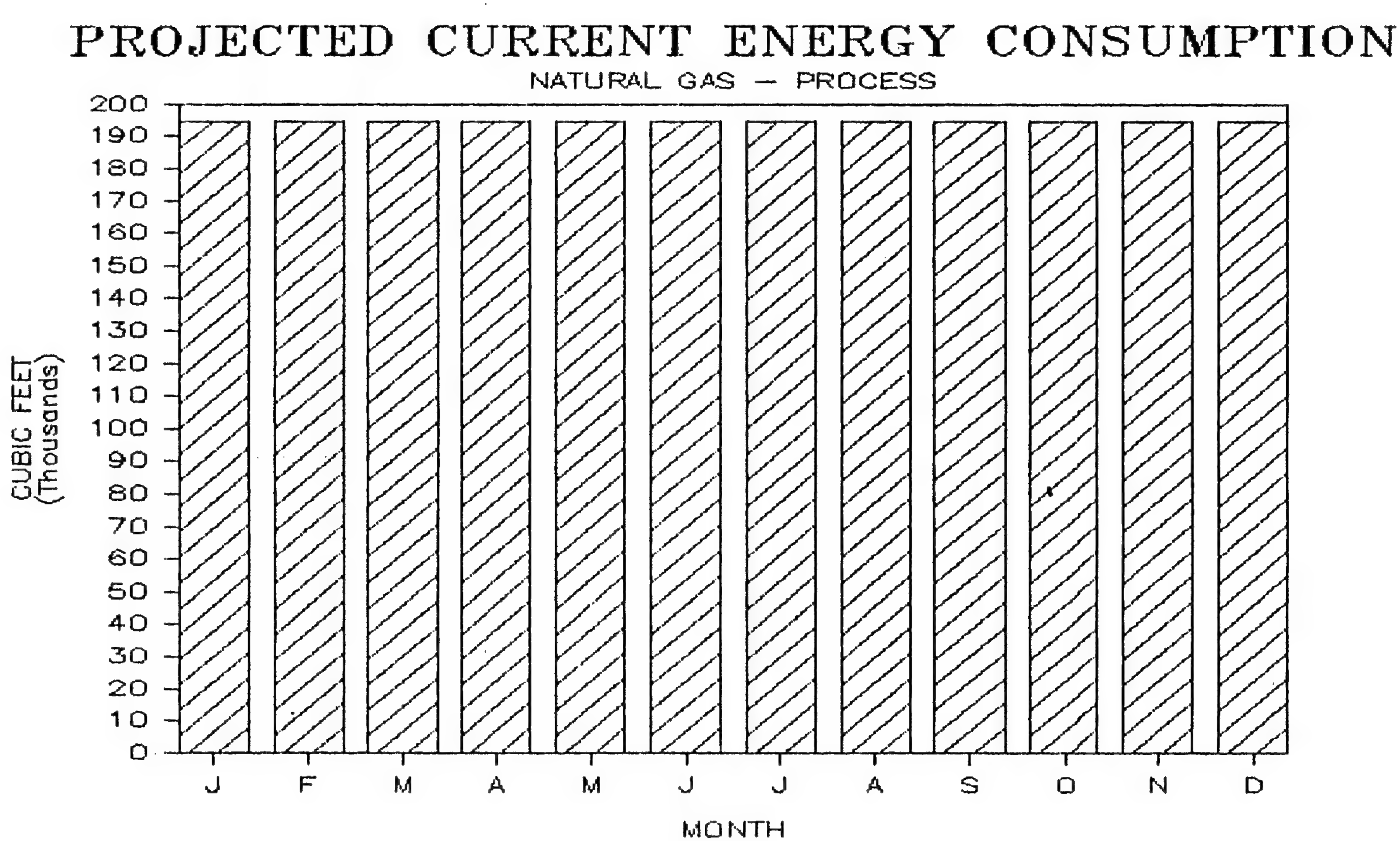
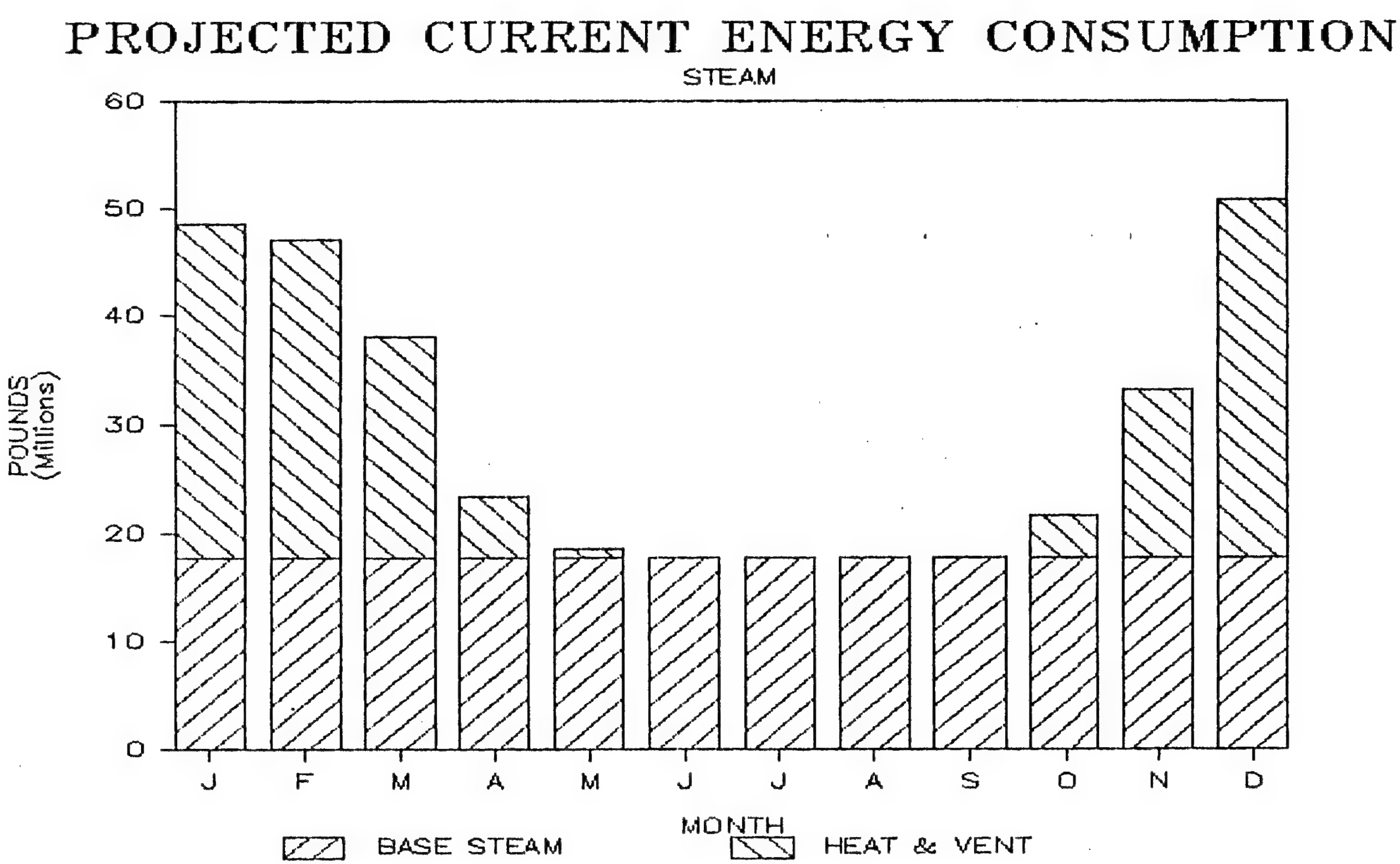

PROJECTED CURRENT ENERGY CONSUMPTION
NATURAL GAS — PROCESS
CUBIC FEET (Thousands)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH

Figure 1.5


PROJECTED CURRENT ENERGY CONSUMPTION
STEAM
POUNDS
(Millions)
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
BASE STEAM
HEAT & VENT

Present heating and ventilation steam requirements are based on the results of the Trace V500 computer analysis (see Table 1.7). This monthly data was then combined with the estimated base steam to yield an annual steam load profile (Figure 1.5).

1.3.5 Conclusions

Building 4 present energy consumption is shown in Figure 1.6, Figure 1.7 and Table 1.8. The energy types have been converted to source requirements using the following conversions:

1 kWH	=	11,600 Btu
1 cf	=	1,031 Btu
1 lb. steam	=	1,000 Btu
% Coal for Steam Production	=	62.18%
% Natural Gas for Steam Production	=	37.82%
Conversion and System Efficiency	=	52%

The present energy consumption profile will be utilized to compare the effectivensss of the proposed ECO's.

Table 1.7

BUILDING 4 HEATING AND VENTILATION LOAD

Month	10^6 lb. Steam
Jan	30.76
Feb	29.28
Mar	20.27
Apr	5.64
May	0.81
Jun	0
Jul	0
Aug	0
Sep	0.03
Oct	3.85
Nov	15.38
Dec	33.02

Figure 1.6

PROJECTED CURRENT ENERGY CONSUMPTION

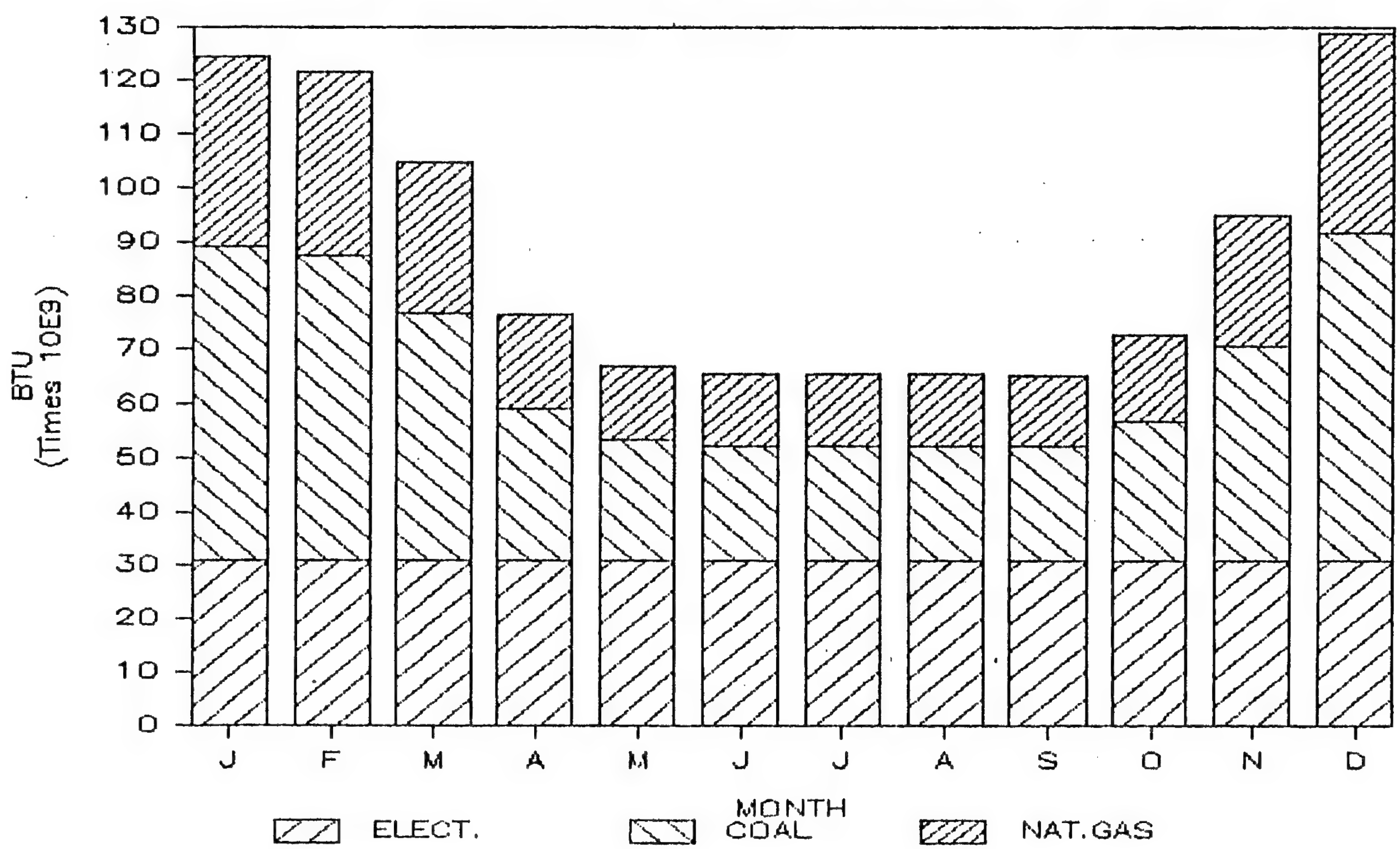


Figure 1.7

PROJECTED CURRENT ENERGY CONSUMPTION

TOTAL SOURCE ENERGY

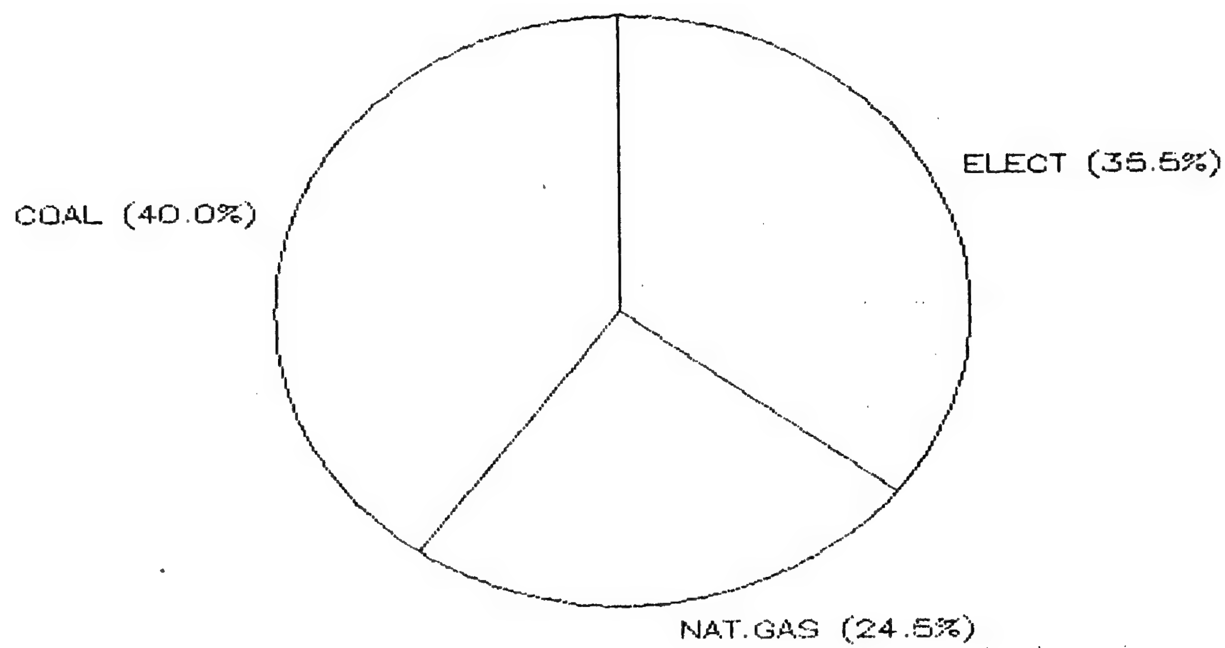


Table 1.8

DATP PROJECTED CURRENT ENERGY CONSUMPTION

	J	F	M	A	M	J	J	A	S	O	N	D
PROCESS												
GAS-CF	194880	194880	194880	194880	194880	194880	194880	194880	194880	194880	194880	194880
GAS-BTU	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08	2.0E+08
HV STEAM-LBS	30760000	29280000	20270000	5640000	810000	0	0	0	30000	3850000	15380000	33020000
HV STEAM-BTU	3.1E+10	2.9E+10	2.0E+10	5.6E+09	8.1E+08	0	0	0	30000000	3.9E+09	1.5E+10	3.3E+10
BASE STEAM-LBS	17765516	17765516	17765516	17765516	17765516	17765516	17765516	17765516	17765516	17765516	17765516	17765516
BASE STEAM-BTU	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10
TOTAL STEAM-LBS	48525516	47045516	38035516	23405516	18575516	17765516	17765516	17765516	17795516	21615516	33145516	50785516
TOTAL STEAM-BTU	4.9E+10	.4.7E+10	3.8E+10	2.3E+10	1.9E+10	1.8E+10	1.8E+10	1.8E+10	1.8E+10	2.2E+10	3.3E+10	5.1E+10
STEAM-SOURCE-BTU	9.3E+10	9.0E+10	7.3E+10	4.5E+10	3.6E+10	3.4E+10	3.4E+10	3.4E+10	3.4E+10	4.2E+10	6.4E+10	9.8E+10
STEAM-GAS-BTU	3.5E+10	3.4E+10	2.8E+10	1.7E+10	1.4E+10	1.3E+10	1.3E+10	1.3E+10	1.3E+10	1.6E+10	2.4E+10	3.7E+10
STEAM-COAL-BTU	5.8E+10	5.6E+10	4.5E+10	2.8E+10	2.2E+10	2.1E+10	2.1E+10	2.1E+10	2.1E+10	2.6E+10	4.0E+10	6.1E+10
ELECT-MWH	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109	2685.109
ELECT-BTU	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09	9.2E+09
ELECT-BTU-S	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10	3.1E+10
GAS-TOTAL-BTU	3.5E+10	3.4E+10	2.8E+10	1.7E+10	1.4E+10	1.3E+10	1.3E+10	1.3E+10	1.3E+10	1.6E+10	2.4E+10	3.7E+10
COAL COST ($)	141634.1	137314.3	111016.3	68314.98	54217.39	51953.20	51853.20	51853.20	51940.76	63090.41	96743.67	148030.5
ELECT. COST ($)	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4	158726.4
N.GAS COST ($)	175084.4	169774.7	137449.8	84962.30	67633.87	64727.87	64727.87	64727.87	63845.31	77550.19	118915.9	180281.7

DATAFILE **CURRENT**

1.4 Production Profile

The historical production profile is not available to the A/E due to the sensitive nature of this information. After discussing this issue with General Dynamics and the Louisville Corps of Engineers, it was decided to use the production rate of 60 tanks per month as a historical average.

This information would be valuable in the determination of production energy consumption on a per tank basis. With this information, it would then be possible to predict the increase or decrease in production energy consumption due to changing production rates.

1.5 **Pending and Prior Projects**

The following is a brief description of pending and prior projects at Building 4, Detroit Arsenal Tank Plant, Warren, Michigan. (See Appendix B, Section C for current PS&ER Report, and Appendix A, Section D for prior ECO documentation.)

1.5.1 Building Envelope

1.5.1.2 Roof

PS&ER Project 84-3 is described as Roof Minor Repair - Building 4. This project addresses roof penetrations identified in the Interim Report. PS&ER Project 86-2 is described as Major Roof Replacement. This project will result in a total R value of 20 for the roof. No further ECO will be developed in this area.

1.5.1.3 Walls

The majority of the building vertical skin was single glazed, factory-type window units. The window units have been replaced with fiberglass and steel panels which have reduced both the conductive and infiltrative losses associated with single glazed window units. The total R value of the new wall section is 14*. No further ECO will be developed in this area.

* Source: Detroit Arsenal Facilities Energy Plan

1.5.1.4 Doors

The doors and entryways at Building 4 have varied utilization rates. Three overhead doors utilize air locks

and one train door utilizes a strip-type door. All overhead doors have been fitted with door heaters under PS&ER Project 81-1.

1.5.1.5 Windows

The windows at Building 4 were replaced at the time insulated wall panels were installed. These windows are aluminum framed, single-pane acrylic. The windows are located along the entire perimter of the building with each window unit being approximately 2 feet 9 inches high by 4 feet wide.

1.5.1.6 Monitors

Existing roof monitors were single glazed and did not have favorable sealing characteristics. PS&ER Projects 79-1, 79-2, 79-5 and 79-6 addressed the monitors. The monitors have been fitted with an insulated panel to obtain a total R value of 12 and gasketing for a more positive seal.

1.5.2 Mechanical Systems

1.5.2.1 Heating and Ventilating Systems

PS&ER Project 81-1 installed heating and ventilating units at Building 4, which included the door heaters at the overhead doors as well as the heating and ventilating units in the majority of the building.

1.5.2.2 Exhaust Systems

PS&ER Project 83-2 included a new exhaust system in the heat/surface treatment area. As this design is not complete, further information is not available.

1.5.2.3 Steam Distribution

Project A1-30-20, Contract No. DACA 45-80-C-0091 (GARD Analysis) included two ECO's which apply to Building 4 steam distribution system. Sub-Project B-1 recommended insulation on steam valves and piping at existing pressure reducing valve (PRV) stations. This project included the 45 PRV stations in the facility, of which 2 are in Building 4. Sub-Project B-1 also recommended the institution of a steam trap inspection program. These two projects have been instituted as an ongoing maintenance item by General Dynamics.

1.5.3 Process Systems

Four ECO's were developed under Project A1-30-20, Contract No. DACA 45-80-C-0091 (GARD Analysis). These ECO's were aimed at the heat/surface treatment area and include:

- Treatment tank insulation.
- Treatment tank covers.
- Water shut off valve.
- Rinse water heat recovery.

It is the A/E's understanding that these ECO's have been considered in the design to be implemented under PS&ER Project 83-2.

1.5.4 Electrical Systems

1.5.4.1 Lighting

Project F-2, Contract No. DACA 45-80-C-0091, recommended the fitting of the fluorescent fixtures in the

general office area with time clocks in order to minimize lighting use during unoccupied hours. This is currently scheduled to be a function of the EMCS installed as PS&ER Project 81-2.

Lighting in the general production/work areas has been converted to high pressure sodium lighting under a prior project.

The study "Load Analysis for Building No. 4", AMC Project 4764565, 21 May 1976, resulted in the entire electrical distribution system of Building 4 to be rehabilitated under Contract No. DACA 45-77-C-0132, dated May 1977. The electrical consumption study, completed as part of Project A1-30-20, Contract No. DACA 45-80-C-0091 (GARD Analysis) dated September 1983, measured electrical consumption at each substation of Building 4 for a period of one week. The recommendations of this report were:

- Evaluation of the feasibility of either replacing transformer 4A with one of greater capacity, or shifting some loads currently served by substation 4A to a neighboring substation.

- The implementation of a second study to trace a low activity period electrical load (1,600 kW, 62 percent) to the "N" panel level and, if necessary, to the "D" panel level.

PS&ER Project 85-8 is described as Substation No. 4 Upgrade and PS&ER Project 85-2 is described as 110 Volt Electrical System - Builidng 4.

1.5.5 Energy Management and Control System

PS&ER Project 81-2 is described as "EMCS". This project is currently in the installation phase.

1.5.6 Interior Spaces

Proposed modifications to interior spaces are:

- General Office Area Renovation, PS&ER Project 88-7
- Gage Lab Facility, PS&ER Project 85-6a
- Material Lab Facility, PS&ER Project 85-4.

1.5.7 Energy Production

An analysis of Building 5 (boiler house) is not included under this project. Since Building 4 is a primary user of energy, it was thought appropriate to mention the cogeneration feasibility study generated from Project Al-30-20, Contract No. DACA 45-80-C-0091 for reference only. The study concluded that the installation of a cogeneration system is feasible and meets ECIP criteria.

1.6 **Energy Conservation Analysis**

1.6.1 Introduction

Starting from the entrance interview to the present, SH&G has proceeded with the project as outlined in Methods and Approaches of the Narrative Summary, Section 2.

The first task was to obtain the basic information needed for the project. The data and information to be provided by the Corps of Engineers and TACOM has been received and incorporated into the project. Part of the data to be provided by General Dynamics was not available. Due to the lack of this information, some aspects of this analysis were not developed. Information obtained by SH&G was developed into survey sheets and zone information sheets (see Appendix B, Sections E and F). From this information, the following ECO's were considered.

ECO No. 1	-	Welding Filter Installation
ECO No. 2	-	Vehicle Adjust Heat Recovery Installation
ECO No. 3	-	Destratification of Plant Air
ECO No. 4	-	Air Curtains
ECO No. 5	-	Storm Sash in Office Area
ECO No. 6	-	Economizer for Office AC Units
ECO No. 7	-	Replace DX Units with Rooftop Units
ECO No. 8	-	Heat Recovery from Wash Booths
ECO No. 9	-	Treatment Tank Condensate Heat Recovery
ECO No. 10	-	Heat/Surface Treatment Area Exhaust Heat Recovery
ECO No. P1	-	Treatment Tank Insulation
ECO No. P2	-	Rinse Water Shutoff Valve
ECO No. P3	-	Rinse Water Heat Recovery
ECO No. P4	-	Treatment Tank Covers

ECO No's. 1 through 10 were initially investigated and ECO No's. P1 through P4 were re-evaluated as they were prior projects developed under Contract No. DACA45-80-C-0091 (GARD Analysis).

During the interim review session, the A/E was advised to take no further action on ECO No's 8 through 10. These ECO's will be addressed in current renovation projects.

In addition to the above investigated ECO's, the items of Annex A of the Scope of Work were commented on as a result of a prior review meeting. This can be found in the Narrative Summary, Section 5.

1.6.2 ECO's Investigated

The following is a brief description of the ECO's, followed by a summary of the life-cycle cost analysis. See Table 1.9 for Summary of Investigated ECO's.

1.6.2.1 ECO No. 1 - Welding Filter Installation

Presently, the buildup of welding fumes in the turret and hull welding areas is being prevented by the relief of large quantities of warm plant air through open roof monitor sections. During the heating season, a significant energy loss is associated with this dumping of heated plant air.

In order to reclaim this energy, the installation of high efficiency media type filters is proposed. These units would allow the warm, previously exhausted air to be recycled for ventilation purposes, and would significantly reduce the amount of outdoor air which would require heating. In total, six 40,000 CFM units are proposed in order to take warm welding fume laden air from high in the bay,

Table 1.9

SUMMARY OF INVESTIGATED ECO's

ECO No.	ECO Description	SIR	Net Annual Energy Saving (MBtu)	CWE ($)	First Year Savings ($)	Total Net Discounted Savings ($)
P2	Rinse Water Shut Off Valve	79.46	1,967.00	1,908.17	9,058.52	142,992.82
P3	Rinse Water Heat Recovery	44.68	2,180.68	3,260.40	8,227.41	137,376.54
P1	Treatment Tank Insulation	9.41	4,807.50	34,121.00	18,138.06	302,859.23
3	Destratification of Plant Air	5.99	22,934.08	176,061.60	86,527.21	994,700.10
P4	Treatment Tank Covers	5.17	1,696.40	15,081.44	6,400.30	73,576.61
1	Welding Filter Installation	3.49	35,029.40	612,849.24	104,744.00	2,016,082.39
4	Air Curtains	2.69	4,826.91	82,260.95	18,039.55	208,957.27
2	Vehicle Adjust Heat Recovery Installation	2.62	17,342.56	427,655.80	56,155.92	1,057,704.23
5	Storm Sash in Office Area	1.14	491.55	28,868.12	1,866.04	30,907.97
7	Economizer for Office A/C Units	0.07	905.26	667,044.40	4,613.20	42,026.30
6	Replace DX Units with Rooftop Unit	0.26	1,868.07	471,313.39	33,740.15	307,372.81

filter the air, and send it back down to the work area. Adequate filtration of this type would allow the monitors to remain closed during the heating season, thus eliminating the large energy wastage associated with the dumping of the heated plant air. The resultant energy savings were estimated using the Trace computer energy estimating program.

ECO No. 1
Analysis Date: April 10, 1985

Construction Cost	$586,458.60
SIOH (4.5%)	$ 26,390.64
Current Working Estimate (CWE)	$612,849.24
Annual Energy Savings	
Natural Gas	15,476.85 MBtu/yr.
Coal	25,445.55 MBtu/yr.
Electricity	-5,893.00 MBtu/yr.
TOTAL	35,029.40 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$ 76,347.30/yr.
Coal	62,112,59/yr.
Electricity	-30,030.73/yr.
SUBTOTAL	$108,429.16/yr.
Annual Recurring	-3,685.16/yr.
TOTAL	$104,744.00/yr.
SIR	3.49

1.6.2.2 <u>ECO No. 2 - Vehicle Adjust Heat Recovery Installation</u>

At present, air is being exhausted through roof monitors in the vehicle adjust areas in order to prevent the buildup of tank vehicle exhaust fumes to hazardous levels. Additionally, since the exhaust through the monitors is uncontrolled, the present exhaust rate is excessive.

The addition of run-around coil type heat recovery units is proposed in these areas in order to bring the exhaust rates down to a controlled, reasonable level and to recover a portion of the heat contained in the air before it is exhausted. Two heat recovery coil units will be incorporated with existing make-up air units and two additional combination heat recovery make-up air units will be installed in order to serve the vehicle adjust areas in K Bay and L Bay, respectively. By recovering some of the heat energy in exhausted air and using this energy to temper incoming outdoor air, steam consumption and energy costs can be signficantly reduced. The resultant energy savings were estimated using the Trace computer energy estimating program.

ECO No. 2
Analysis Date: April 10, 1985

Construction Cost	$409,240.00
SIOH (4.5%)	$ 18,415.80
Current Working Estimate (CWE)	$427,655.80
Annual Energy Savings	
Natural Gas	7,826.68 MBtu/yr.
Coal	12,867.88 MBtu/yr.
Electricity	-3,352.00 MBtu/yr.
TOTAL	17,342.56 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$ 38,609.01/yr.
Coal	31,410.50/yr.
Electricity	-17,081.79/yr.
SUBTOTAL	$ 52,937.72/yr.
Annual Recurring	3,218,20/yr.
TOTAL	$ 56,155.92/yr.
SIR	2.62

1.6.2.3 ECO No. 3 - Destratification of Plant Air

At present, HV units 1 through 27 are fitted with diffusers having a horizontal throw distribution pattern. Because of this design, heated air from the HV units is being delivered to and remains in the truss space. This delivery of air at truss level combined with warm air's natural tendancy to rise, creates a temperature gradient in the space, with the work place down at floor level being the coldest, and the truss space, which is unoccupied, being the warmest. This leads to both greater conductive heat loss through the roofing material and greater energy loss associated with roof exfiltration losses. This stratification is to be reduced by the installation of long vertical throw diffusers which will help bring the warm air from the HV units in the truss space down to the work place. This will help to create a more uniform temperature distribution from floor to ceiling and will reduce the energy wastage associated with stratification.

The resultant energy savings were estimated using the Trace computer energy estimating program.

ECO No. 3
Analysis Date: April 10, 1985

Construction Cost	$168,480.00	
SIOH (4.5%)	$ 7,581.60	
Current Working Estimate (CWE)	$176,061.60	
Annual Energy Savings		
Natural Gas	8,673.67	MBtu/yr.
Coal	14,260.41	MBtu/yr.
Electricity	0	
TOTAL	22,934.08	MBtu/yr.

Annual Dollar Savings	
Natural Gas	$ 42,787.21/yr.
Coal	34,809.66/yr.
Electricity	0
SUBTOTAL	$ 77,596.87/yr.
Annual Recurring	8,930.34/yr.
TOTAL	$ 82,527.21/yr.
SIR	5.99

1.6.2.4 Interactive Effects of ECO No. 1, ECO No. 2 and ECO No. 3 - Welding Filter Installation, Vehicle Adjust Heat Recovery and Destratification

Since ECO No. 1, ECO No. 2 and ECO No. 3 have interactive effects on one another, it is necessary to determine the combined effect of implementing all ECO's simultaneously. Therefore, the Trace computer model was used to estimate the combined energy savings assuming all three ECO's were implemented.

ECO No's. 1, 2 and 3
Analysis Date: April 10, 1985

Construction Cost	$1,164,178.60
SIOH (4.5%)	$ 52,388.04
Current Working Estimate (CWE)	$1,216,566.64
Annual Energy Savings	
Natural Gas	31,175.23 MBtu/yr.
Coal	52,255.00 MBtu/yr.
Electricity	-9,245.00 MBtu/yr.
TOTAL	73,185.23 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$ 153,787.41/yr.
Coal	125,113.46/yr.
Electricity	-47,112.52/yr.
SUBTOTAL	$ 231,788.34/yr.
Annual Recurring	7,637.76/yr.
TOTAL	$ 239,426.10/yr.
SIR	3.82

1.6.2.5 <u>ECO No. 4 - Air Curtains</u>

There are three energy conservation strategies which could be utilized at an entryway. They are airlocks, strip doors, and air curtains.

Airlocks require a small energy input, but are easily bypassed. It takes time for a tank to go through one door, wait for it to close, then wait for the next door to open. Because of this inconvenience, air locks are bypassed. During the A/E's visit to the facility, airlocks were never used as intended.

Strip doors lack a positive seal and are easy to destroy. Door No. 37 at Building 4 illustrates how strip doors are cut to keep from interfering with traffic flows.

Air curtains utilize a controlled stream of air aimed across an open door to create an air seal. They are effective in reducing infiltration which occurs when the door is open. Air curtains require an energy input, but are not as frequently bypassed as they do not slow the flow of traffic.

ECO No. 4
Analysis Date: April 10, 1985

Construction Cost	$78,910.00
SIOH (4.5%)	$ 3,350.95
Current Working Estimate (CWE)	$82,260.95
Annual Energy Savings	
Natural Gas	1,874.63 MBtu/yr.
Coal	3,082.08 MBtu/yr.
Electricity	-129.80 MBtu/yr.
TOTAL	4,826.91 MBtu/yr.

Annual Dollar Savings	
Natural Gas	$ 9,247.55/yr.
Coal	7,523.36/yr.
Electricity	-661.46/yr.
SUBTOTAL	$16,109.45/yr.
Annual Recurring	2,573.47/yr.
TOTAL	$18,039.55/yr.
SIR	3.61

1.6.2.6 ECO No. 5 - Storm Sash on Office Windows

The general office area along the north perimeter presently incorporates a single glazed window system. The majority of these windows are operable. The single glazed windows can be fit with a storm sash. This will result in a savings due to decreased conduction and infiltration losses associated with the present system.

ECO No. 5
Analysis Date April 10, 1985

Construction Cost	$27,625.00
SIOH (4.5%)	$ 1,243.12
Current Working Estimate (CWE)	$28,868.12
Annual Energy Savings	
Natural Gas	182.59 MBtu/yr.
Coat	300.20 MBtu/yr.
Electricity	8.76 MBtu/yr.
TOTAL	491.55 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$ 900.63/yr.
Coal	732.79/yr.
Electricity	44.64/yr.
SUBTOTAL	$ 1,678.05/yr.
Annual Recurring	187.99/yr.
TOTAL	$ 1,866.14/yr.
SIR	1.14

1.6.2.7 ECO No. 6 - Economizer for Office A/C Units

The general office area is served by many different units. The majority of these units are Chrysler Air-Temp 10-ton units. The primary function of these units is to remove the internal heat gain of the space. These units are 100 percent recirculation.

These units can be modified to allow for 100 percent outside air when the conditions are correct, or a portion of outdoor air will be mixed with return air to provide for proper discharge conditions. This will require the addition of economizer controls and ductwork from the units to an outside air source.

ECO No. 6
Analysis Date: April 10, 1985

Construction Cost	$638,320.00
SIOH (4.5%)	$ 28,724.40
Current Working Estimate (CWE)	$667,044.40
Annual Energy Savings	
Natural Gas	0
Coal	0
Electricity	905.26 MBtu/yr
TOTAL	905.26 MBtu/yr.
Annual Dollar Savings	
Natural Gas	0
Coal	0
Electricity	$ 4,613.20/yr.
SUBTOTAL	$ 4,613.20/yr.
Annual Recurring	0
TOTAL	$ 4,613.20/yr.
SIR	0.07

1.6.2.8 ECO No. 7 - Replace DX Units with Rooftop Units

The general office area is served by many different units. The primary function of these units is to remove the internal heat gain of the space. These units are 100 percent recirculation.

These units can be eliminated and replaced with rooftop units. As agreed in the interim review, the A/E is to perform a basic evaluation of this proposed ECO.

ECO No. 7
Analysis Date: April 10, 1985

Construction Cost	$451,071.60
SIOH (4.5%)	$ 20,295.79
Current Working Estimate (CWE)	$471,313.39
Annual Energy Savings	
Natural Gas	0
Coal	0
Electricity	1,868.07 MBtu/yr.
TOTAL	1,868.07 MBtu/yr.
Annual Dollar Savings	
Natural Gas	0
Coal	0
Electricity	$ 9,519.68/yr.
SUBTOTAL	$ 9,519.68/yr.
Annual Recurring	24,220.47/yr.
TOTAL	$ 33,740.15/yr.
SIR	0.26

1.6.2.9 ECO No. P1 - Treatment Tank Insulation

The surface treatment area prepares the surface of components which require painting or plating. The renovated surface treatment area will contain 7 tanks which will

maintain a temperature above ambient. These tanks remain at their operating temperature 24 hours per day.

Treatment tanks primarily lose energy through conduction and evaporation. Conduction through tank sides and bottom can be the most easily controlled of the two means of heat loss. The insulation should be protected by a coating which is resistant to the chemicals utilized in this area and should offer good resistance to impact.

ECO No. P1
Analysis Date: April 10, 1985

Construction Cost	$32,652.00	
SIOH (4.5%)	$ 1,469.00	
Current Working Estimate (CWE)	$34,121.00	
Annual Energy Savings		
Natural Gas	1,818.20	MBtu/yr.
Coal	2,989.50	MBtu/yr.
Electricity	0	
TOTAL	4,807.70	MBtu/yr.
Annual Dollar Savings		
Natural Gas	$ 8,969.18/yr.	
Coal	7,297.37/yr.	
Electricity	0	
SUBTOTAL	$16,266.55/yr.	
Annual Recurring	1,872.00/yr.	
TOTAL	$18,188.06/yr.	
SIR	9.41	

1.6.2.10 ECO No. P2 - Treatment Tank Water Shutoff Valve

The hot water rinse tank is continually receiving fresh water. The fresh water must be raised to the tank operating temperature, while water already at the tank

operating temperature is being discharged. This is a continually occurring process, even when the tank is not in use.

A water shutoff valve should be integrated with the water supply line to modulate the supply of fresh water to the tank during periods of predicted inactivity. This will eliminate some of the unnecessary water changes and save the associated energy required to raise the fresh water to the tanks operating temperature. The shutoff valve should be integrated with either a timer or with the proposed EMCS (see Narrative Summary, Section 3).

To eliminate problems commonly associated with time clocks, it is the A/E's recommendation that the water shutoff valve be integrated with the proposed EMCS.

ECO No. P2
Analysis Date: April 10, 1985

Construction Cost	$1,826.00
SIOH (4.5%)	$ 82.17
Current Working Estimate (CWE)	$1,908.17
Annual Energy Savings	
Natural Gas	744.00 MBtu/yr.
Coal	1,223.00 MBtu/yr.
Electricity	0
TOTAL	1,967.00 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$3,670.15/yr.
Coal	2,985.34/yr.
Electricity	0
SUBTOTAL	$6,655.50/yr.
Annual Recurring	2,403.02/yr.
TOTAL	$9,058.52/yr.
SIR	79.46

1.6.2.11 ECO No. P3 - Hot Water Rinse Heat Recovery

The hot water rinse tank is continually receiving fresh water. This fresh water must be raised to the tank operating temperature, while water already at the tank operating temperature is being discharged. Presently, this is a continually occurring process.

A tube-shell heat exchanger can be integrated with the supply and discharge lines to reclaim a portion of the energy required to raise the 55°F entering water to 160°F.

ECO No. P3
Analysis Date: April 10, 1985

Construction Cost	$3,120.00
SIOH (4.5%)	$ 140.40
Current Working Estimate (CWE)	$3,260.40
Annual Energy Savings	
Natural Gas	824.73 MBtu/yr.
Coal	1,355.95 MBtu/yr.
Electricity	0
TOTAL	2,180.68 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$4,068.39/yr.
Coal	3,309.87/yr.
Electricity	0
SUBTOTAL	$7,378.27/yr.
Annual Recurring	849.14/yr.
TOTAL	$8,227.41/yr.
SIR	44.68

1.6.2.12 ECO No. P2 and ECO No. P3 - Water Shutoff Valve with Rinse Heat Recovery - Synergistic Effects

If both P2 (water shutoff valve) and P3 (rinse water heat recovery) are implemented, the savings are not additive. These ECO's affect the quantity and quality of the rinse water. Consequently, these ECO's are evaluated together.

ECO No's. P2 and P3
Analysis Date: April 10, 1985

Construction Cost	$ 4,946.00
SIOH (4.5%)	$ 222.57
Current Working Estimate (CWE)	$ 5,168.57
Annual Energy Savings	
Natural Gas	1,391.73 MBtu/yr.
Coal	2,288.15 MBtu/yr.
Electricity	0
TOTAL	3,679.88 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$ 6,865.40/yr.
Coal	5,585.37/yr.
Electricity	0
SUBTOTAL	$12,450.78/yr.
Annual Recurrding	3,069.92/yr.
TOTAL	$15,520.70/yr.
SIR	51.47

1.6.2.13 ECO No. P4 - Treatment Tank Covers

The surface treatment area prepares the surface of the components requiring painting or plating. The renovated surface treatment area will contain 7 tanks which will be

significantly above the ambient temperature. An additional tank will be near ambient.

Treatment tanks primarily lose energy through conduction and evaporation. Evaporation is further accelerated at higher tank temperatures and with air movement across the exposed surface. Tank covers can be installed to reduce the evaporative heat loss of these treatment tanks.

Three types of covers were analyzed in the prior study. They were passive, motorized and manual (see Narrative Summary, Section 3 for discussion of the types). It is the A/E's recommendation that manual covers be utilized.

ECO No. P4
Analysis Date: April 10, 1985

Construction Cost	$14,432.00
SIOH (4.5%)	$ 649.44
Current Working Estimate (CWE)	$15,081.44
Annual Energy Savings	
Natural Gas	641.58 MBtu/yr.
Coal	1,054.82 MBtu/yr.
Electricity	0
TOTAL	1,696.40 MBtu/yr.
Annual Dollar Savings	
Natural Gas	$ 3,164.91/yr.
Coal	2,574.82/yr.
Electricity	0
SUBTOTAL	$ 5,739.73/yr.
Annual Recurring	660.57/yr.
TOTAL	$ 6,400.30/yr.
SIR	5.17

1.6.3 ECO's Recommended

Of the investigated ECO's, the following are recommended for implementation:

ECO No. 1 - Welding Filter Installation
ECO No. 2 - Vehicle Adjust Heat Recovery
ECO No. 3 - Destratification of Plant Air
ECO No. 4 - Air Curtains
ECO No. 5 - Storm Sash in Office Area
ECO No. P1 - Treatment Tank Insulation
ECO No. P2 - Rinse Water Shutoff Valve
ECO No. P3 - Rinse Water Heat Recovery
ECO No. P4 - Treatment Tank covers

See Tables 1.10 and Table 1.11 for Summary of Recommended ECO's and Figure 1.8 through Figure 1.13 for graphic presentation of the energy reduction of the recommended ECO's.

Table 1.10

SUMMARY OF RECOMMENDED ECO's

ECO No.	ECO Description	SIR	Net Annual Energy Saving (MBtu)	CWE ($)	First Year Savings ($)	Total Net Discounted Savings ($)	Payback
P2	Rinse Water Shut Off Valve	79.46	1,967.00	1,908.17	9,058.52	142,992.82	.2
P3	Rinse Water Heat Recovery	44.68	2,180.68	3,260.40	8,227.41	137,376.54	.4
P1	Treatment Tank Insulation	9.41	4,807.50	34,121.00	18,138.06	302,859.23	1.9
3	Destratification of Plant Air	5.99	22,934.08	176,061.60	86,527.21	994,700.10	2.0
P4	Treatment Tank Covers	5.17	1,696.40	15,081.44	6,400.30	73,576.61	2.4
1	Welding Filter Installation	3.49	35,029.40	612,849.24	104,744.00	2,016,082.39	5.9
4	Air Curtains	2.69	4,826.91	82,260.95	18,039.55	208,957.27	4.6
2	Vehicle Adjust Heat Recovery Installation	2.62	17,342.56	427,655.80	56,155.92	1,057,704.23	7.6
5	Storm Sash in Office Area	1.14	491.55	28,868.12	1,866.04	30,907.97	15.5

Table 1.11

SYNERGISTIC EFFECTS OF RECOMMENDED ECO's

ECO's	SIR	Net Annual Energy Savings (MBtu)	CWE ($)	First Year Savings ($)	Total Net Discounted Savings ($)
P2, P3	51.47	3,679.88	5,168.57	15,520.70	20,893.21
1, 2, 3	3.82	73,185.23	1,216,566.64	239,426.10	4,384,974.68

Figure 1.8

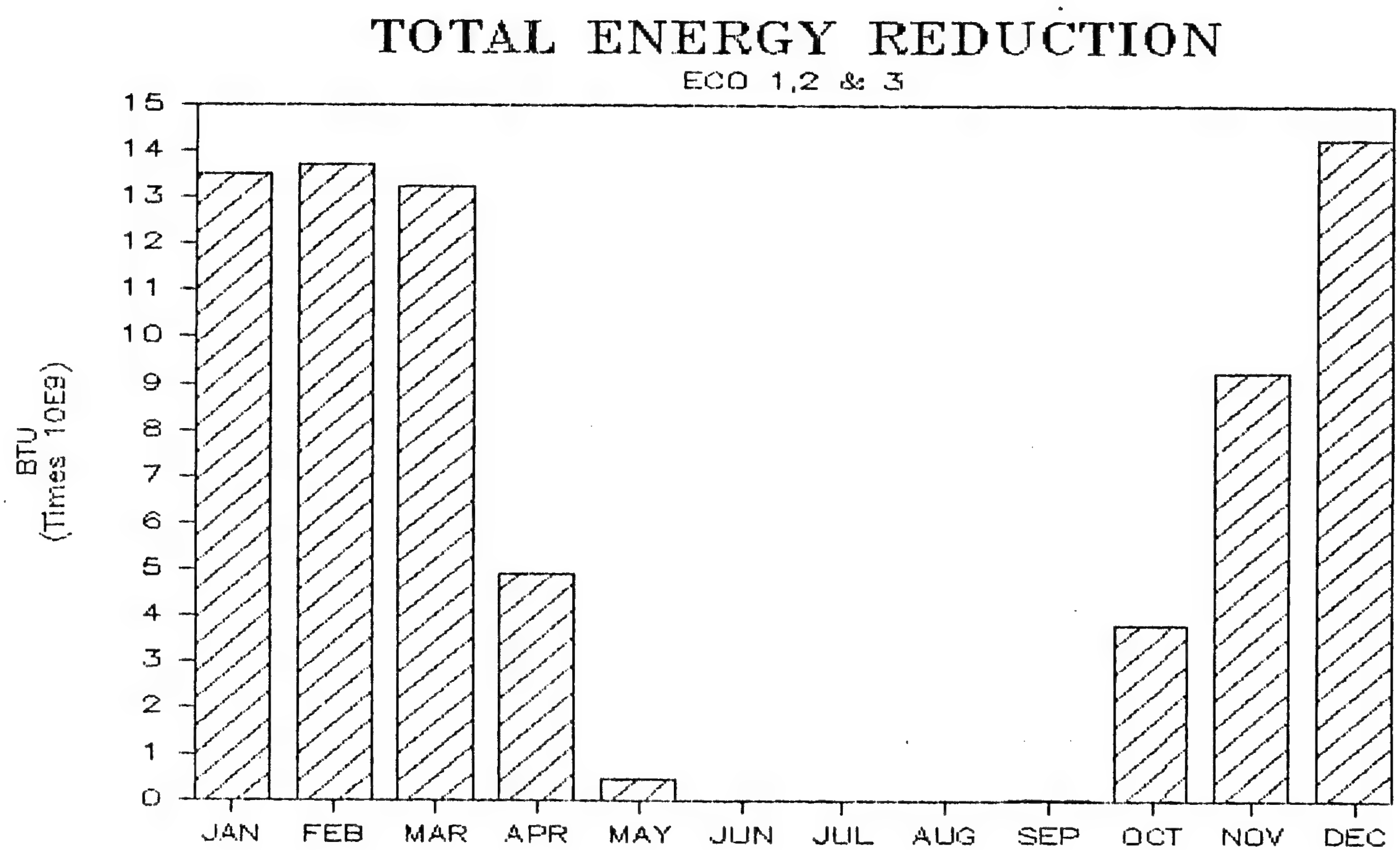
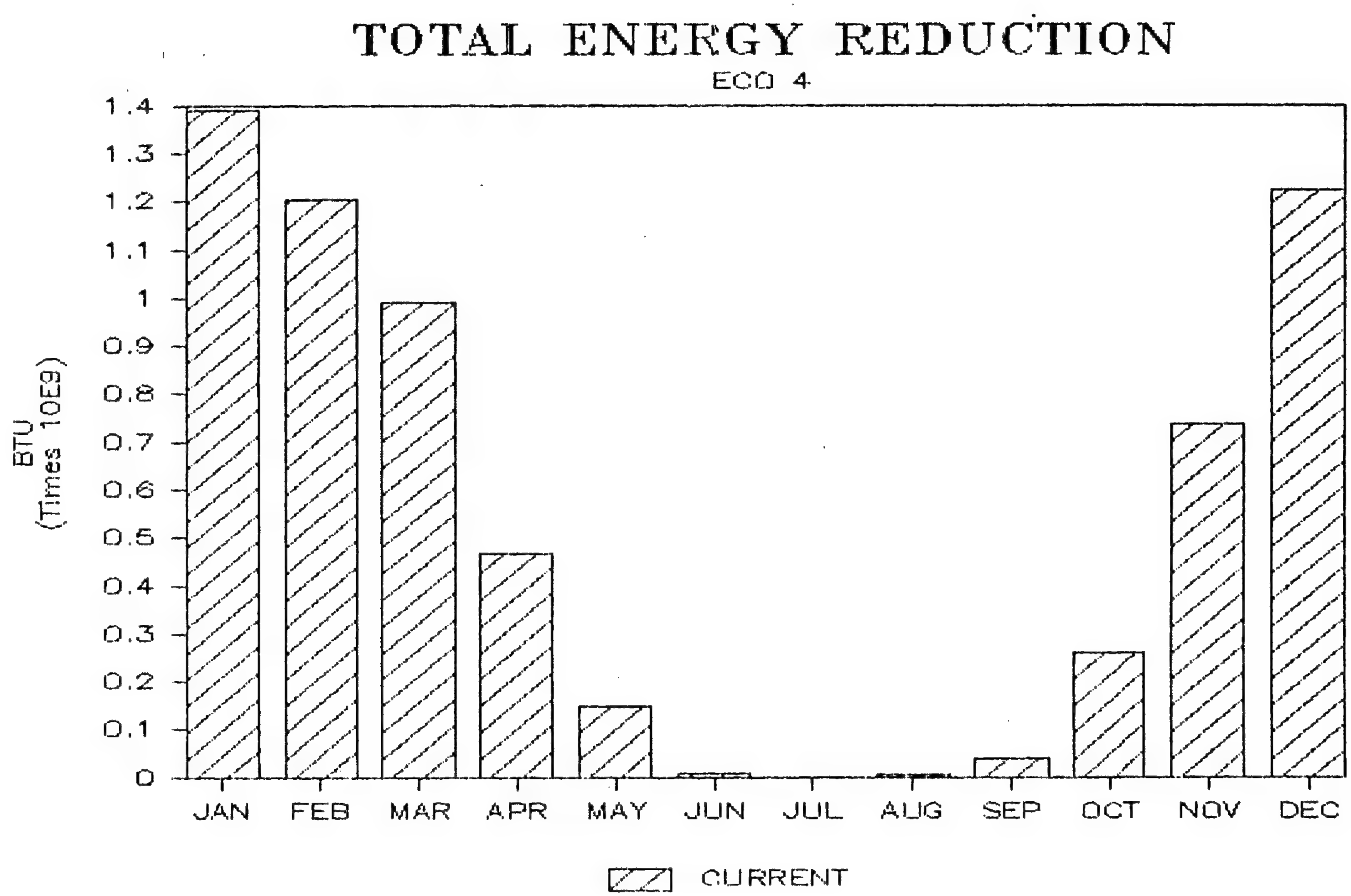
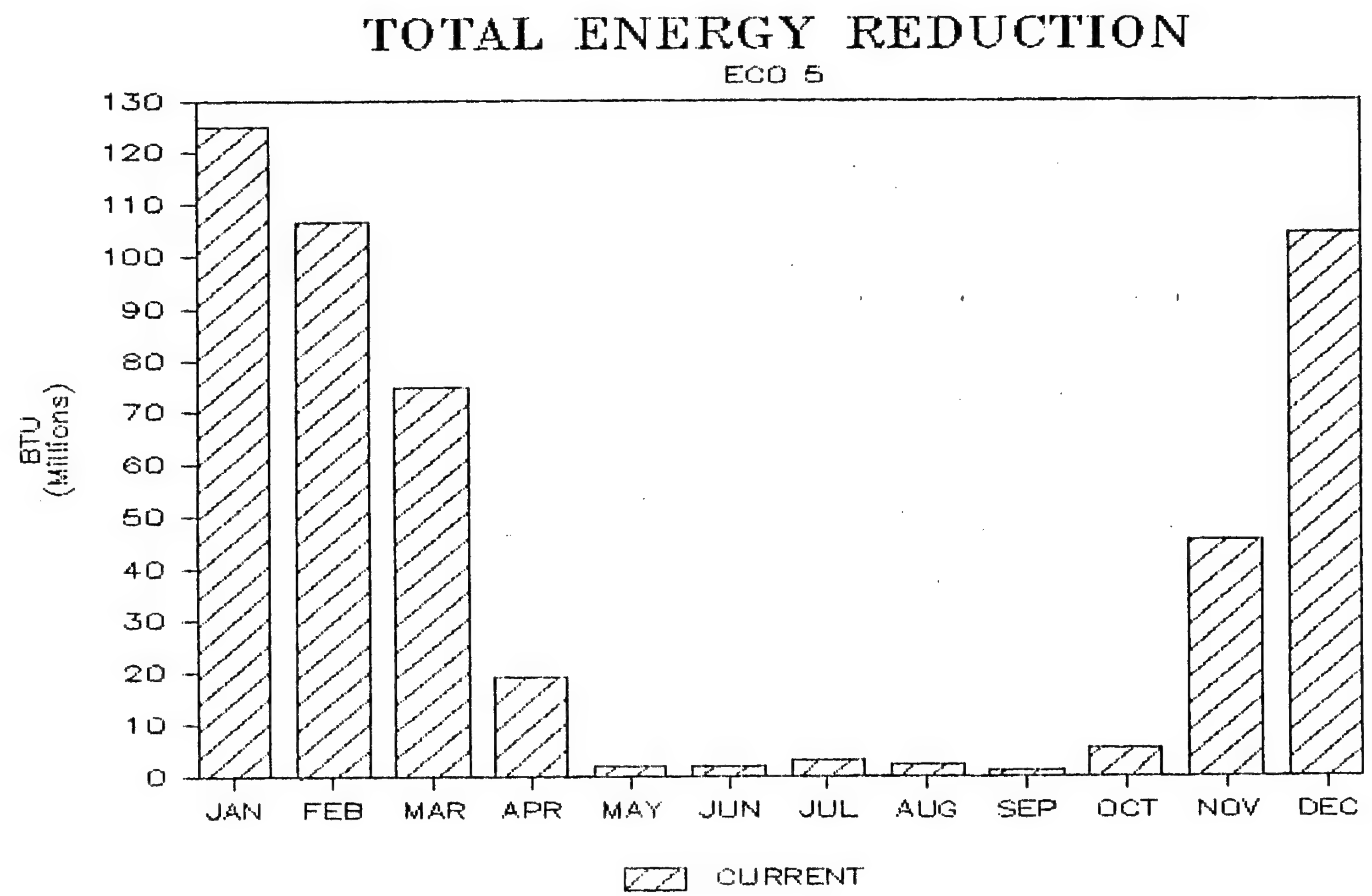

TOTAL ENERGY REDUCTION
ECO 1,2 & 3
BTU
(Times 10E9)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 1.9



TOTAL ENERGY REDUCTION
ECO 4
BTU
(Times 10E9)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
CURRENT

Figure 1.10



TOTAL ENERGY REDUCTION
ECO 5
BTU (Millions)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
CURRENT

Figure 1.11

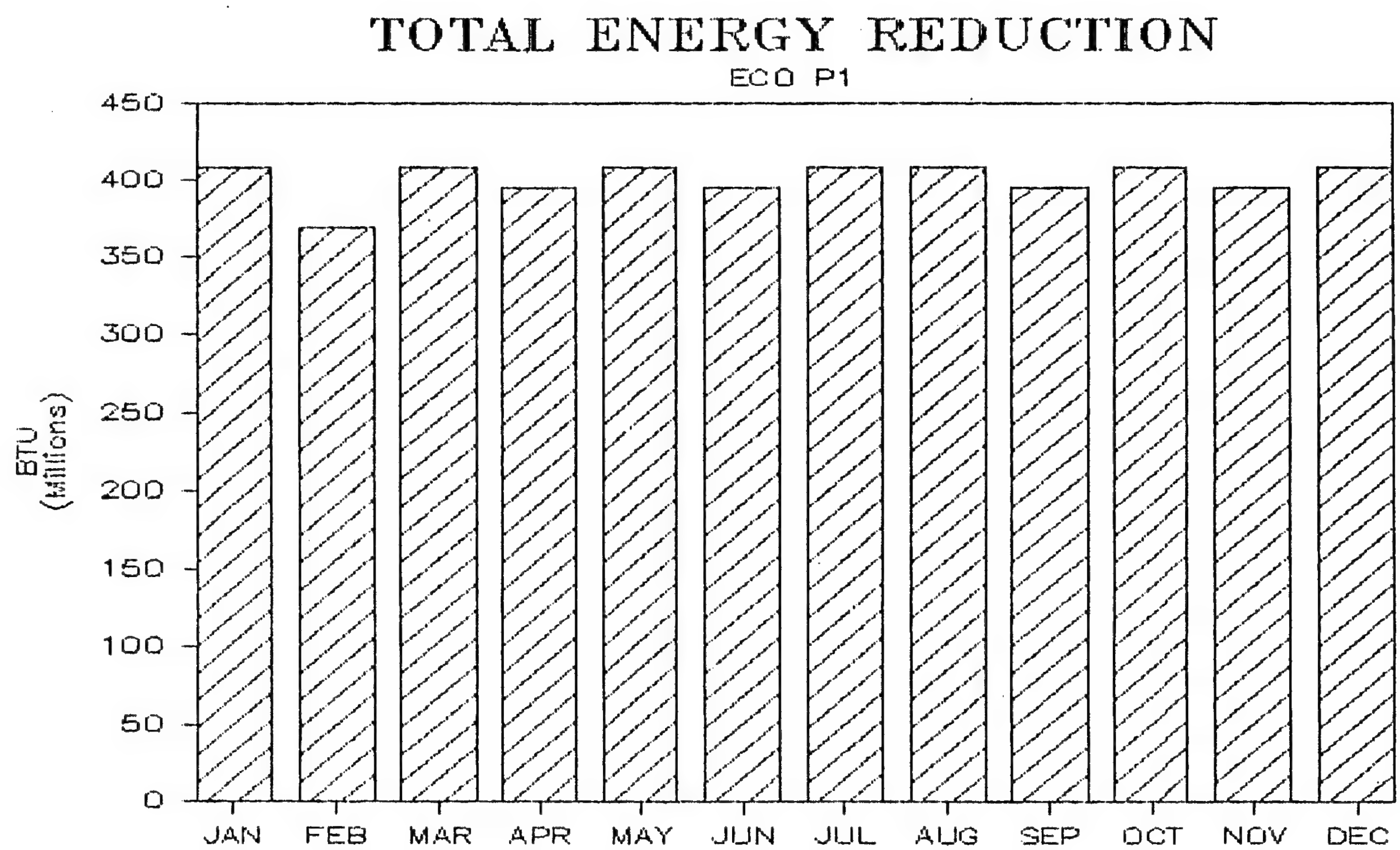
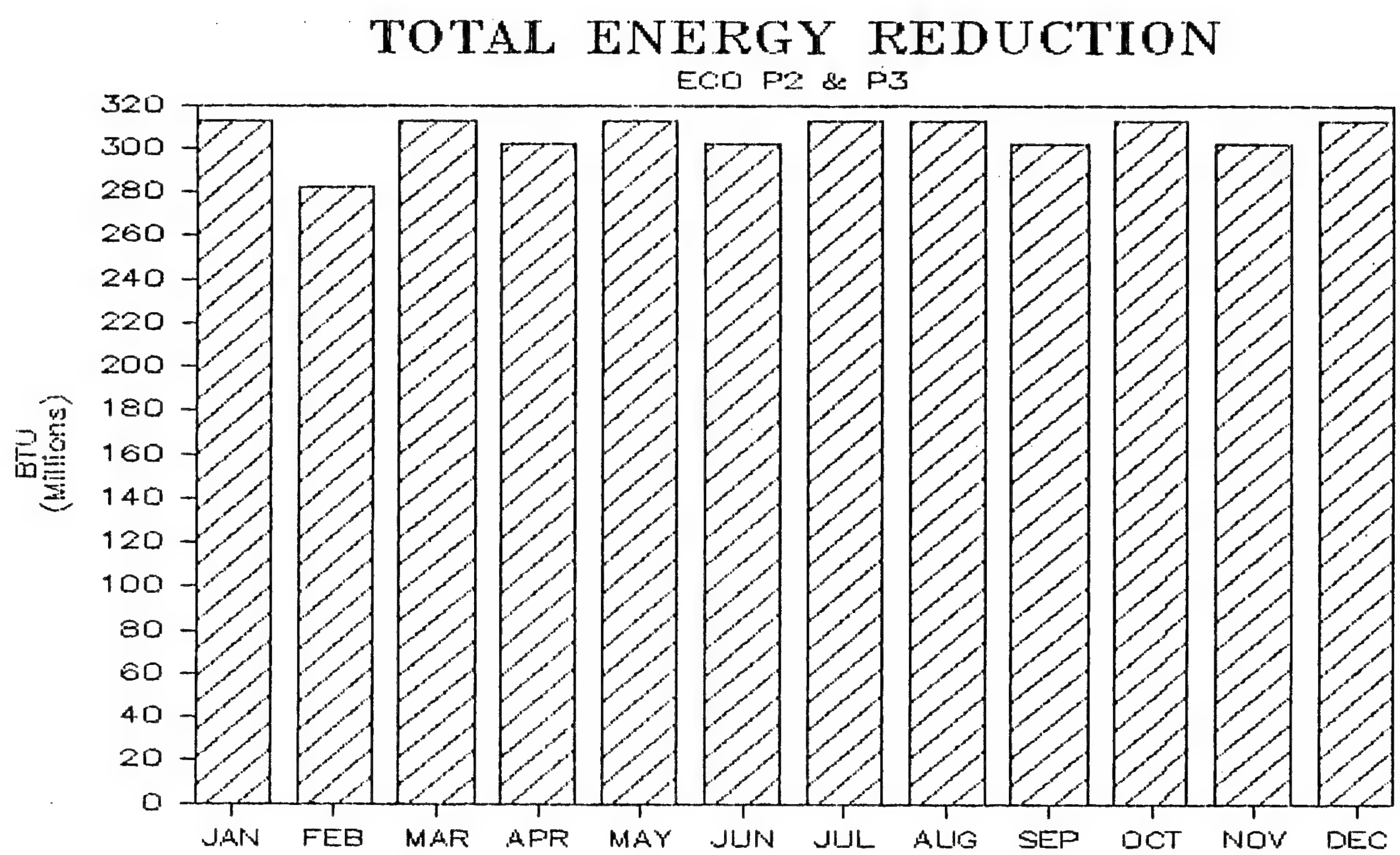
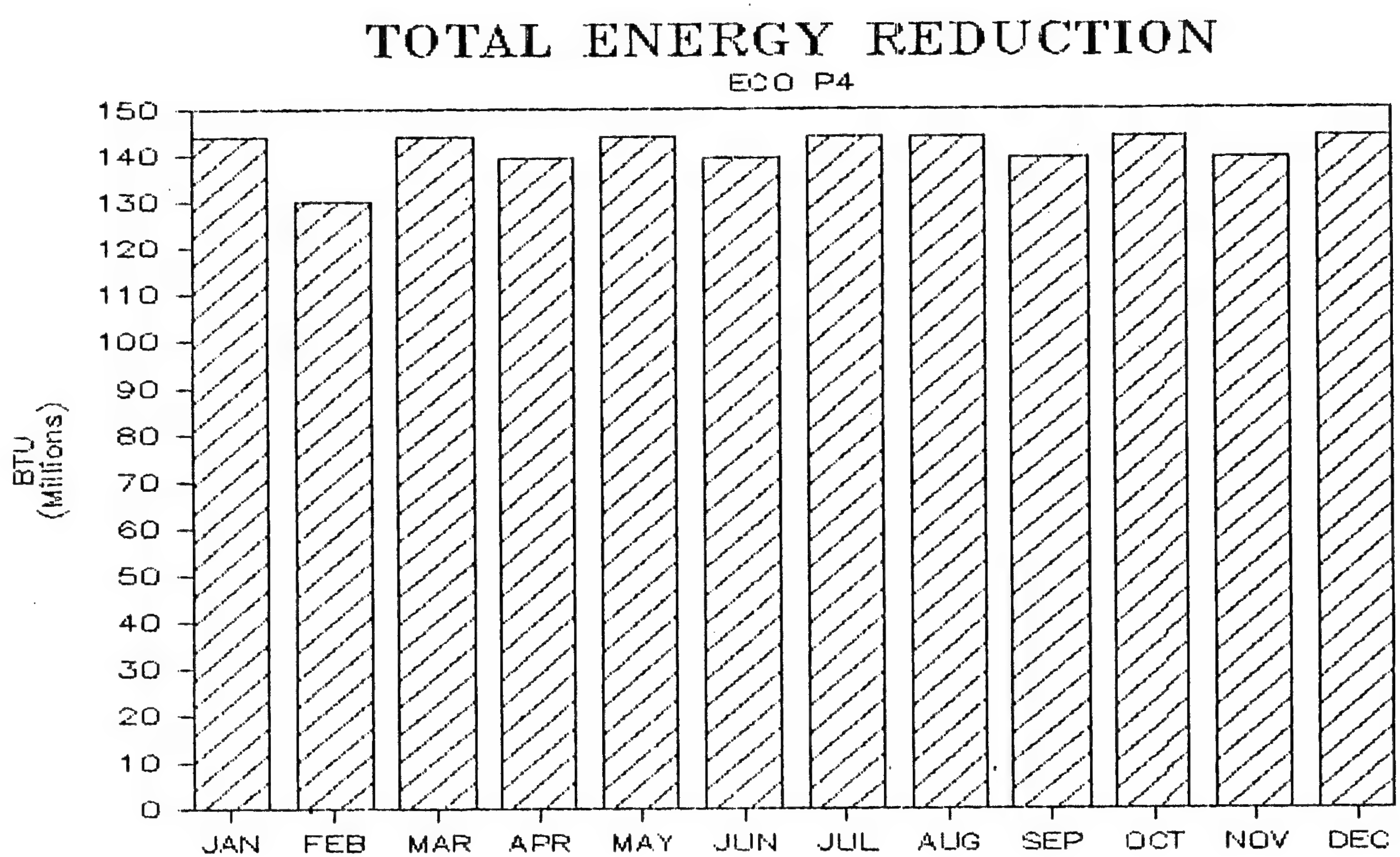

TOTAL ENERGY REDUCTION
ECO P1
BTU (Millions)
450
400
350
300
250
200
150
100
50
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 1.12



TOTAL ENERGY REDUCTION
ECO P2 & P3
BTU (Millions)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 1.13



TOTAL ENERGY REDUCTION
ECO P4
BTU (Millions)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

1.7 Energy and Cost Savings

1.7.1 Introduction

The following ECO's have been recommended for implementation at Building 4:

ECO No. 1	-	Welding Filter Installation
ECO No. 2	-	Vehicle Adjust Heat Recovery
ECO No. 3	-	Destratification of Plant Air
ECO No. 4	-	Air Curtains
ECO No. 5	-	Storm Sash in Office Area
ECO No. P1	-	Treatment Tank Insulation
ECO No. P2	-	Rinse Water shutoff Valve
ECO No. P3	-	Rinse Water Heat Recovery
ECO No. P4	-	Treatment Tank Covers

The implementation of the above ECO's will yeild the following energy and cost savings.

1.7.2 Electrical Consumption

The electrical consumption at Building 4 will increase after the implementation of the recommended ECO's. Table 1.12 summarizes the change in electrical consumption per ECO. This data is then utilized with information from Table 1.8 of Section 1.3 of the Executive Summary to generate Table 1.13. Using the totals in Table 1.13, the existing electrical energy cost is $1,904,717.50 per year, and the proposed electrical energy cost is $1,952,446.69 per year. This is a 2.5 percent increase in electrical consumption. See Figure 1.14 for existing versus proposed electrical consumption.

Table 1.12

CHANGE IN ELECTRICAL CONSUMPTION
(10^6 Btu)

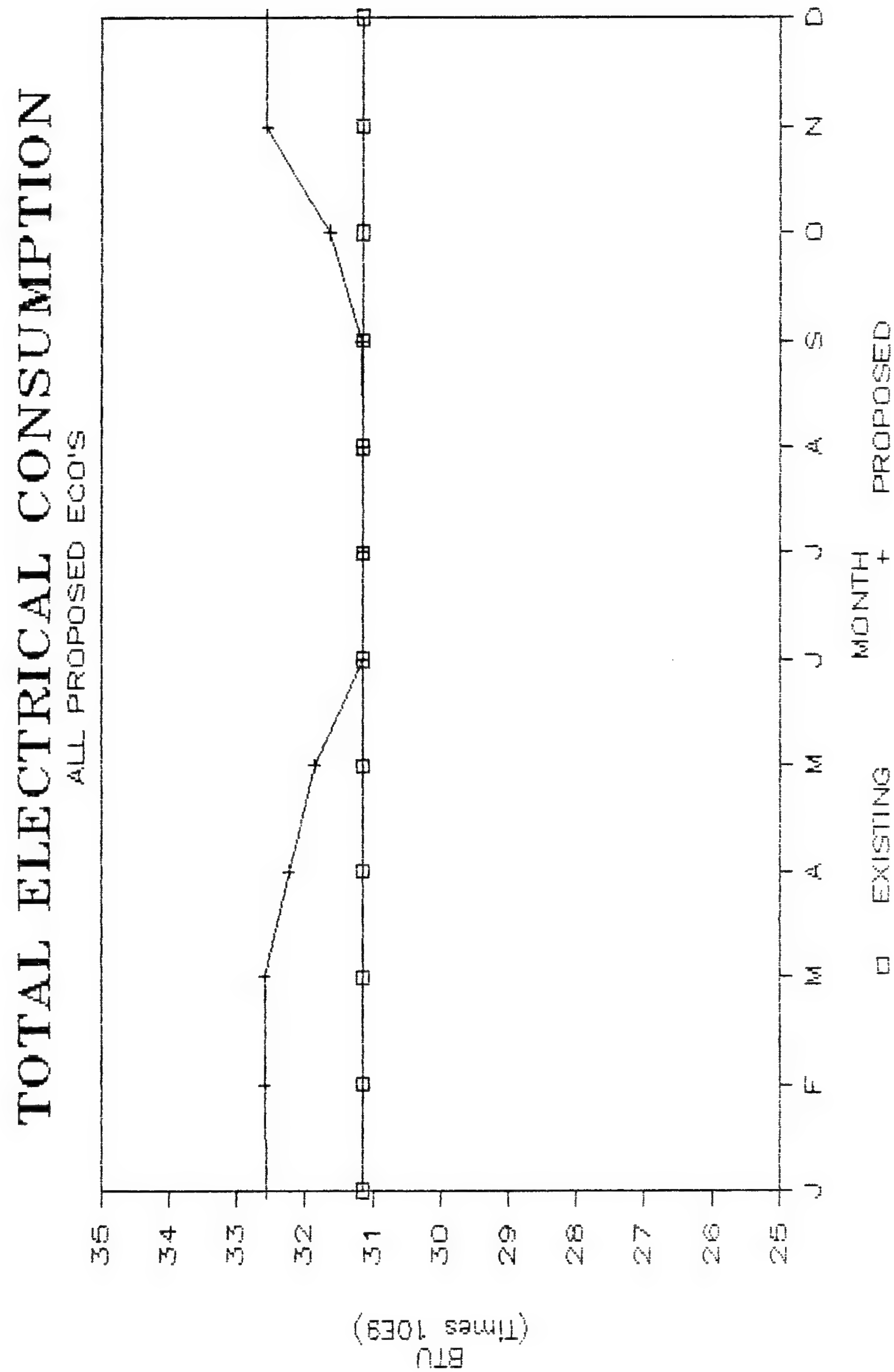
	ECO 1,2 & 3	ECO 4	ECO 5	ECO P1	ECO P2,P3	ECO P4	Total
Jan	1,394.96	27.86	0	0	0	0	1,422.81
Feb	1,324.49	24.13	0	0	0	0	1,348.62
Mar	1,430.19	19.86	0	0	0	0	1,450.05
Apr	1,084.46	9.36	-0.061	0	0	0	1,093.77
May	716.71	2.99	-0.438	0	0	0	719.26
June	0	0.21	-2.015	0	0	0	-1.81
Jul	0	0	-3.013	0	0	0	-3.01
Aug	0	0.10	-2.348	0	0	0	-2.25
Sep	19.82	0.81	-0.788	0	0	0	19.84
Oct	484.46	5.18	-0.096	0	0	0	489.54
Nov	1,394.96	14.76	0	0	0	0	1,409.71
Dec	1,394.96	24.52	0	0	0	0	1,419.48
				TOTAL			9,366.01

Table 1.13

TOTAL ELECTRICAL CONSUMPTION
(Btu)

	Existing	Proposed
Jan	31,147,264,400	32,570,074,400
Feb	31,147,264,400	32,495,884,400
Mar	31,147,264,400	32,597,314,400
Apr	31,147,264,400	32,241,034,400
May	31,147,264,400	31,866,524,400
Jun	31,147,264,400	31,145,454,400
Jul	31,147,264,400	31,144,254,400
Aug	31,147,264,400	31,145,014,400
Sep	31,147,264,400	31,167,104,400
Oct	31,147,264,400	31,636,804,400
Nov	31,147,264,400	32,556,974,400
Dec	31,147,264,400	32,566,744,400
TOTAL	$373,767.17 \times 10^6$	$383,133.18 \times 10^6$

Figure 1.14


TOTAL ELECTRICAL CONSUMPTION
ALL PROPOSED ECO'S
BTU
(Times 10E9)
35
34
33
32
31
30
29
28
27
26
25
J
F
M
A
M
J
J
A
S
O
N
D
MONTH
EXISTING
PROPOSED

1.7.3 Natural Gas Consumption

The natural gas consumption at Building 4 will decrease after the implementation of the recommended ECO's. Table 1.14 summarizes the change in natural gas consumption per ECO. This data is then utilized with information from Table 1.8 of Section 1.3 of the Executive Summary to generate Table 1.15. Using the totals in Table 1.15, the existing natural gas cost is $1,271,602.69 per year and the proposed natural gas cost is $1,087,32.55 per year. This is a 14.5 percent decrease in natural gas consumption. See Figure 1.15 for existing versus proposed natural gas consumption.

1.7.4 Coal Consumption

The coal consumption at Building 4 will decrease after the implementation of the recommended ECO's. Table 1.16 summarizes the change in coal consumption per ECO. This data is then utilized with information from Table 1.8 of Section 1.3 of the Executive Summary to generate Table 1.17. Using the totals in Table 1.17, the existing coal cost is $1,028,062.30 per year and the proposed coal cost is $879,221.01 per year. This is a 14.5 percent decrease in coal consumption. See Figure 1.16 for existing versus proposed coal consumption.

1.7.5 Conclusions

The total energy consumption at Building 4 will decrease after the implementation of all recommended ECO's. Table 1.18 summarizes the monthly change in energy consumption by energy source. This translates into the following energy cost savings:

Table 1.14

CHANGE IN NATURAL GAS CONSUMPTION
(10^6 Btu)

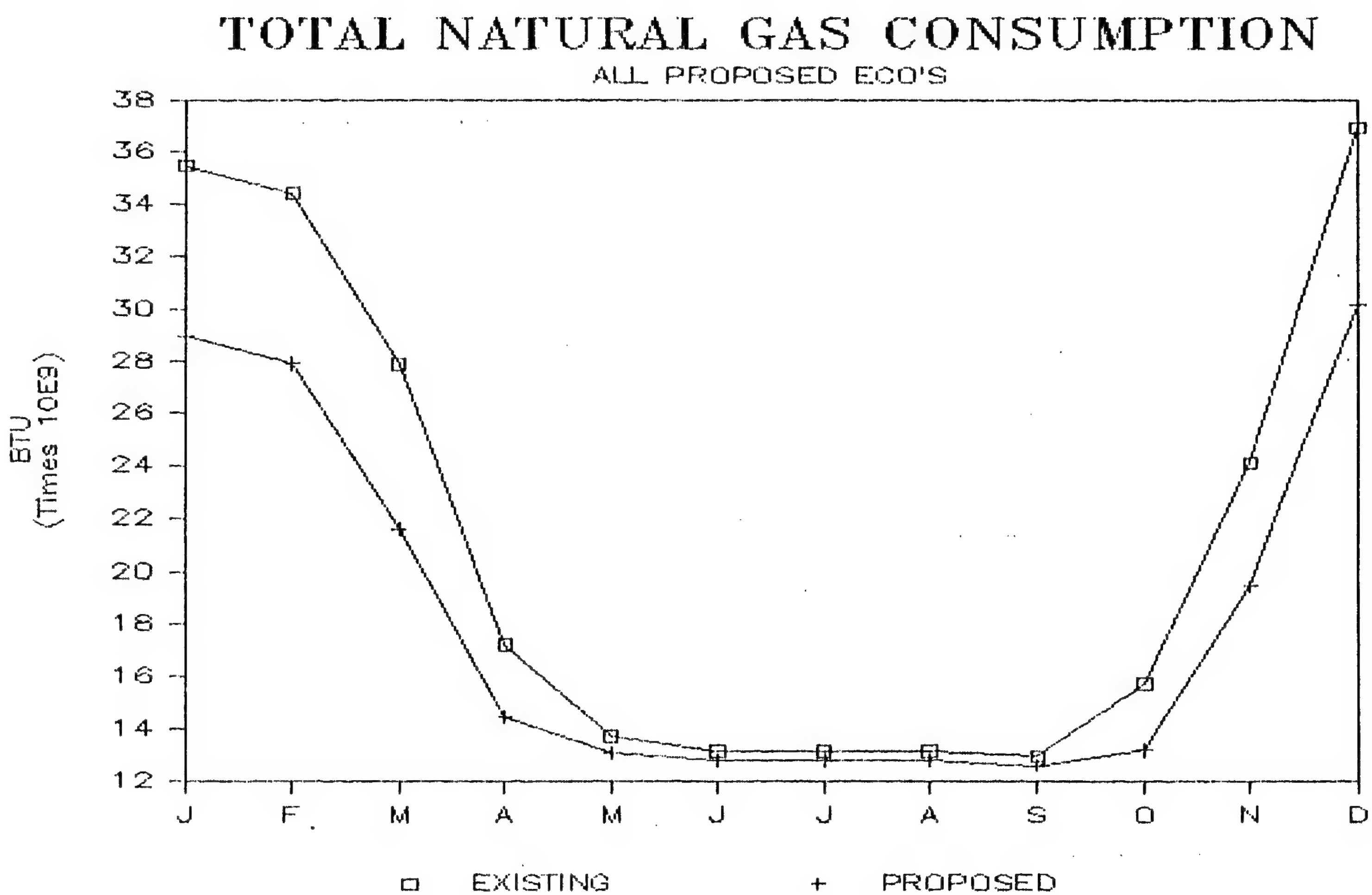
	ECO 1,2 & 3	ECO 4	ECO 5	ECO P1	ECO P2,P3	ECO P4	Total
Jan	5,635.0	402.30	47.35	154.42	118.20	54.49	6,411.76
Feb	5,680.7	348.53	40.31	139.48	106.76	49.22	6,365.00
Mar	5,544.3	286.87	28.28	154.42	118.20	54.49	6,186.56
Apr	2,269.6	135.35	7.23	149.44	114.39	52.73	2,728.74
May	264.3	43.24	6.62	154.42	118.20	54.49	635.27
Jun	0	3.01	0	149.44	114.39	52.73	319.57
Jul	0	0	0	154.42	118.20	54.49	327.11
Aug	0	1.50	0	154.42	118.20	54.49	328.61
Sep	19.8	11.66	0.12	149.44	114.39	52.73	348.14
Oct	1,809.9	74.82	2.06	154.42	118.20	54.49	2,213.89
Nov	4,032.2	213.18	17.19	149.44	114.39	52.73	4,579.13
Dec	5,919.4	354.17	39.43	154.42	118.20	54.49	6,640.11
					TOTAL		37,083.89

Table 1.15

TOTAL NATURAL GAS CONSUMPTION
(Btu)

	Existing	Proposed
Jan	35,492,490,621	29,080,700,621
Feb	34,416,118,293	28,051,118,293
Mar	27,863,338,107	21,676,778,107
Apr	17,223,252,189	14,494,512,189
May	13,710,496,550	13,075,226,550
Jun	13,121,400,884	12,801,830,884
Jul	13,121,400,884	12,794,290,884
Aug	13,121,400,884	12,792,790,884
Sep	12,942,492,842	12,594,352,842
Oct	15,720,697,094	13,233,917,094
Nov	24,106,219,353	19,527,089,353
Dec	36,935,413,857	30,295,303,857
TOTAL	$257,774.72 \times 10^6$	$220,417.91 \times 10^6$

Figure 1.15



TOTAL NATURAL GAS CONSUMPTION
ALL PROPOSED ECO'S
BTU
(Times 10E9)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
J
F
M
A
M
J
J
A
S
O
N
D
EXISTING
PROPOSED

Table 1.16

CHANGE IN COAL CONSUMPTION
(10^6 Btu)

	ECO 1,2 & 3	ECO 4	ECO 5	ECO P1	ECO P2,P3	ECO P4	Total
Jan	9,264.57	661.42	77.87	253.88	194.34	89.59	10,541.64
Feb	9,339.66	573.02	66.27	229.31	175.53	80.92	10,464.75
Mar	9,115.46	471.65	46.50	253.88	194.34	89.59	10,171.46
Apr	3,731.49	222.53	11.88	245.70	188.06	86.70	4,486.36
May	434.53	71.09	1.02	253.88	194.34	89.59	1,044.42
Jun	0	4.95	0	245.70	188.06	86.70	525.41
Jul	0	0	0	253.88	194.34	89.59	537.81
Aug	0	2.47	0	253.88	194.34	89.59	540.28
Sep	32.52	19.16	0.20	245.70	188.06	86.70	572.32
Oct	2,975.67	123.01	3.38	253.88	194.34	89.59	3,639.87
Nov	6,629.32	350.49	28.27	245.70	188.06	86.70	7,528.52
Dec	9,732.10	582.29	64.83	253.88	194.34	89.59	10,917.03
					TOTAL		60,969.87

Table 1.17

TOTAL COAL CONSUMPTION
(Btu)

	Existing	Proposed
Jan	58,022,997,927	47,481,357,927
Feb	56,253,330,255	45,788,580,255
Mar	45,479,880,441	35,308,420,441
Apr	27,986,476,359	23,491,106,359
May	22,211,141,997	21,166,721,997
Jun	21,242,607,663	20,717,197,663
Jul	21,242,607,663	20,704,797,663
Aug	21,242,607,663	20,702,327,663
Sep	21,278,479,305	20,706,159,305
Oct	25,846,135,053	22,209,615,053
Nov	39,632,802,795	32,104,282,795
Dec	60,725,328,291	49,808,295,291
TOTAL	$421,164.40 \times 10^6$	$360,188,86 \times 10^6$

Figure 1.16

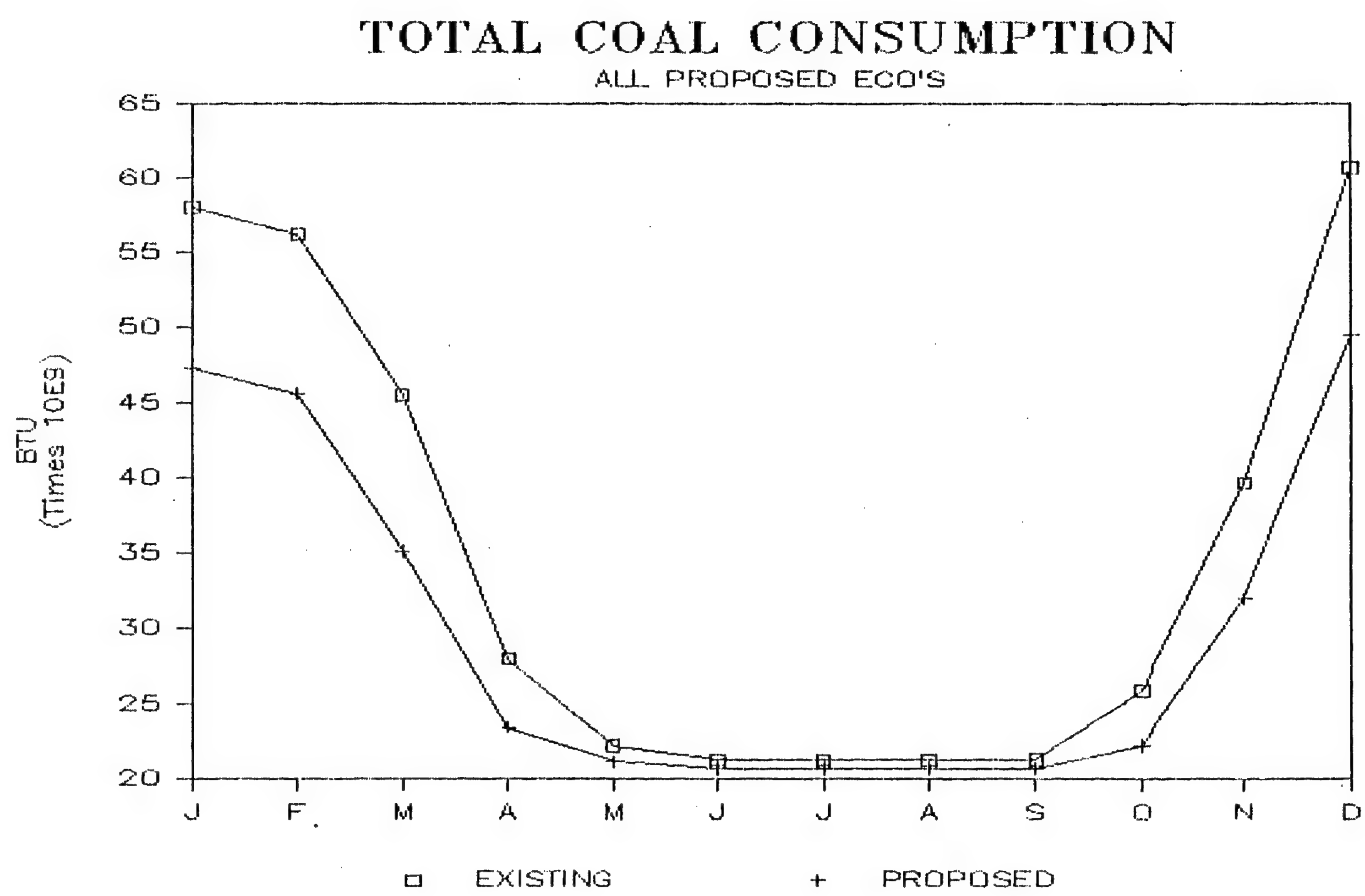

TOTAL COAL CONSUMPTION
ALL PROPOSED ECO'S
BTU
(Times 10E9)
65
60
55
50
45
40
35
30
25
20
J
F
M
A
M
J
J
A
S
O
N
D
EXISTING
+ PROPOSED

Table 1.18

CHANGE IN ENERGY CONSUMPTION - ALL ECO's
(10^6 Btu)

	Coal	Natural Gas	Electricity	Net
Jan	-10,541.64	- 6,411.79	1,422.81	-15,530.62
Feb	-10,464.75	- 6,365.00	1,348.62	-15,481.13
Mar	-10,171.46	- 6,186.56	1,450.05	-14,907.97
Apr	- 4,486.36	- 2,728.74	1,093.77	- 6,121.33
May	- 1,044.42	- 635.27	719.26	- 960.43
Jun	- 525.41	- 319.57	- 1.81	- 846.79
Jul	- 537.81	- 327.11	- 3.01	- 867.93
Aug	- 540.28	- 328.61	- 2.25	- 871.14
Sep	- 572.32	- 348.14	19.84	- 900.62
Oct	- 3,639.87	- 2,213.89	489.54	- 5,364.32
Nov	- 7,528.52	- 4,579.13	1,409.71	-10,697.94
Dec	-10,917.03	- 6,640.11	1,419.47	-16,137.67
TOTAL	-60,969.87	-37,083.89	9,366.01	-88,687.79

$$\text{Coal} = \frac{60{,}969.87 \times 10^6 \text{ Btu}}{\text{yr.}} \times \frac{\$2.441}{10^6 \text{ Btu}}$$

$$= \$148{,}827.45/\text{yr.}$$

$$\text{Natural Gas} = \frac{37{,}083.89 \times 10^6 \text{ Btu}}{\text{yr.}} \times \frac{\$4.933}{10^6 \text{ Btu}}$$

$$= \$182{,}934.83/\text{yr.}$$

$$\text{Electricity} = \frac{9{,}366.01 \times 10^6 \text{ Btu}}{\text{yr.}} \times \frac{\$4.096}{10^6 \text{ Btu}}$$

$$= -\$47{,}729.19/\text{yr.}$$

Total Energy Cost Savings = \$284,033.09/yr.

The total energy consumption before and after implementation of ECO's is listed in Table 1.19. This is an 8.4 percent decrease in energy consumption at Building 4.

See figure 1.17 for existing versus proposed total energy consumption.

Table 1.19

TOTAL ENERGY CONSUMPTION
(10^6 Btu)

	Existing	Proposed
Jan	124,662.75	109,132.13
Feb	121,816.71	106,335.58
Mar	104,490.48	89,582.51
Apr	76,356.99	70,235.66
May	67,068.91	66,108.48
Jun	65,511.27	64,664.48
Jul	65,511.27	64,643.34
Aug	65,511.27	64,640.13
Sep	65,368.24	64,467.62
Oct	72,714.10	67,349.88
Nov	94,886.29	84,188.35
Dec	128,808.01	112,670.34
TOTAL	1,052,706.29	964,018.50

Figure 1.17

TOTAL ENERGY CONSUMPTION

ALL PROPOSED ECOS